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APPLE GROWING IN CALIFORNIA

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CONTENTS

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GENERAL REVIEW OF THE APPLE INDUSTRY

PERHAPS BECAUSE CALIFORNIA PRODUCES a greater variety of fruits than any other state and leads in the production of almonds, apricots, peaches, pears, prunes, and walnuts, as well as lemons and oranges, the importance of the apple crop is usually underestimated. According to statistics,[2] the total production of apples in California in 1927 and in 1930 was exceeded by only two other states—Washington and New York. In

TABLE 1

PRODUCTION AND VALUE OF CALIFORNIA APPLES, 1926–1935.

Year	Production	Farm value per bushel, December 1	Total value
	bushels	*dollars*	*dollars*
1926	10,350,000	0.40	4,140,000
1927	7,458,000	0.90	6,712,000
1928	13,105,000	0.50	6,553,000
1929	7,880,000	0.90	7,092,000
1930	11,644,000	0.55	6,404,000
1931	9,112,000	0.65	5,923,000
1932	9,045,000	0.32	2,824,000
1933	9,333,000	0.50	4,666,000
1934	6,500,000	0.49	3,185,000
1935	9,889,000	0.37	3,659,000
Average	9,431,600	0.56	5,115,800

Sources of data:
1926–1928: California Coöperative Crop Reporting Service. California Crop Report, 1928. California State Dept. Agr. Spec. Pub. 96:36. 1929.
1929–1935: California Coöperative Crop Reporting Service, annual reports. Sacramento. (Mimeo.)

1924, 1928, 1929, 1932, and 1933 it was exceeded only by these states and by Virginia or Pennsylvania. In 1935 the state was fifth in total production. Only occasionally do Michigan, Ohio, and West Virginia force California below fifth or sixth rank. The production and value of California apples during the decade from 1926 to 1935 is shown in table 1. Yields, in some years, have fluctuated widely, but there has been an average production of approximately 9½ million bushels.

From 1919 to 1925, inclusive, the average farm value of the crop was $1.20 a bushel. Since 1925 average returns have been only about half

[1] Associate Pomologist in the Experiment Station.

[2] United States Department of Agriculture Yearbooks, annual issues, 1930–1935.

this amount. Despite these low returns in most years, the total value of the apple crop has averaged approximately two and one-half times that of either the cherries or the shipping plums, nearly twice that of the almonds, three-fourths that of the pears, and nearly two-thirds that of the apricots. These data on production and returns indicate that the apple is relatively important even though the acreage for 1936 is now only 70 per cent or less of that for 1925.

New plantings in the past decade have been limited, largely confined to small areas, and in most counties have not offset older trees that, for one reason or another, have been removed. Bearing acreage in the Pajaro Valley is now only about 60 per cent of that for 1925. San Bernardino County, the third largest apple district of the state in 1925, has now dropped from nearly 6,000 acres to approximately 1,600. Other southern and central San Joaquin Valley counties have suffered similar losses, while Inyo County, containing 1,000 acres in 1926, is now estimated to contain less than 100. Mendocino, Humboldt, Butte, Placer, and El Dorado counties have experienced little change. The bearing acreage in Napa County has increased slightly since 1928, while that in Sonoma County has gradually increased over the previous decade. The Sebastopol area now contains a slightly greater acreage of trees than the Pajaro Valley. Tuolumne County, estimated to have had less than 1,000 bearing acres in 1925, doubled that number during the next two years and has since shown a slight increase. Estimated bearing and nonbearing acreages of apples in each county of the state may be obtained from the Agricultural Statistician, State Department of Agriculture, Sacramento.

CHOOSING A LOCATION FOR APPLE GROWING

Apples may be grown under a rather wide range of conditions. A commercial apple orchard, however, represents a long-time investment. In selecting its location, therefore, one should duly consider such factors as (1) suitable climatic conditions, (2) good soil, (3) ample water supply, (4) transportation and market facilities.

Climatic Requirements.—Thought should be given to summer and winter temperatures, frost damage, winds, and fog.

Apple trees thrive and fruit best under a relatively long, cool, slow, growing season. Except, perhaps, for early summer varieties in favorable locations, apples are not being produced successfully under interior-valley conditions. Suitable size and good texture are difficult to secure where high temperatures are combined with low humidity. Furthermore, sunburn damage is often serious on the fruit. In California, therefore, the best apple districts are those where summer temperatures are con-

sidered too low for the optimum development of other tree fruits, except perhaps pears. For this reason commercial production is limited to rather definite sections receiving coastal influences or to those in the interior at an altitude of 2,000 to 4,000 feet. In either of these locations summer temperatures are moderate.

At elevations of 3,500 feet or higher, and in the Sacramento and San Joaquin valleys, there is usually enough winter chilling to permit satisfactory opening of the buds of most varieties in spring. This is true also, for the varieties grown, in coastal regions in the northern part of the state. In some southern districts there is very harmful delay in opening of leaf buds and flower buds in springs following the warmest winters. Temperatures in any part of the state are rarely so severe as to cause winter injury to apple trees; but at altitudes above 3,500 feet the crop is frequently endangered or even lost by reason of late spring frosts. Coastal sections are particularly free from frost damage.

Any location subject to strong winds during the growing period should be avoided. Beside the possibility of blowing the fruit from the trees at harvest time, much damage may occur through limb rubbing.

Fogs, as already mentioned, may help in coastal sections to break the rest period of trees in the spring. In the growing season, however, excessive fog prevents full color development of red or striped varieties and may also cause more or less russeting, which renders the fruit less attractive. For these reasons fruit of highest color and finish is usually produced in fog-free areas at higher altitudes.

Soil.—Apple orchards have been planted both on stiff, heavy clay and on sandy soils; but an intermediate type ranging from clay loam to silt or sandy loam is preferable. Such soils are easier to work than those which are heavier; are likely to be more fertile and have a higher moisture-holding capacity than the sandy soils. Good drainage is essential; the tree roots should strike to a considerable depth without reaching the water table. Shallow soils or soils underlaid with hardpan or gravel should preferably be avoided.

Different varieties of apples often show special suitability to certain types of soil. In the Watsonville section the Yellow Newtown does better on heavier soils than the Yellow Bellflower. The Gravenstein, likewise, is apparently well adapted to the fine, sandy loam of the Sebastopol section. With only a few varieties, however, have such soil adaptations been determined with any degree of certainty.

Water Supply.—Most apple orchards of California depend entirely upon natural rainfall for their water supply. Others receive one or two irrigations. Usually, where the average annual precipitation amounts to

as much as 20 inches, that amount has been thought sufficient for satisfactory tree growth. Though it may, under favorable soil and climatic conditions, produce growth the first few years, it may prove inadequate after the trees reach bearing age. Even where the rainfall is as much as 40 inches, irrigation is sometimes beneficial, either because of an open, porous soil of low water holding capacity or because all the rain comes at one season and some is lost through surface runoff and by deep percolation.

Bearing trees need an adequate water supply to produce a large crop and bring it to proper size. In most sections, rains are not expected during the latter part of the growing season; hence irrigation facilities will enable one to apply water when most needed.

Transportation Facilities.—Extension of highways and of trucking facilities has materially decreased the transportation problem of smaller districts far from their markets. In certain hilly areas, however, several miles from the highway, fruit must be hauled over unimproved roads. The grower thus located is obviously at some disadvantage and must use every precaution to protect his fruit, usually unpacked, from excessive bruising.

Market Facilities.—Either the larger producing districts are provided with coöperative or private selling organizations that grade, pack, and ship most of the crop sold as fresh fruit, or else the fruit passes through the hands of individual buyers or packers. Apples used for drying may likewise be purchased by owners of commercial evaporators or dried by individual growers. In the smaller districts the best part of the dessert varieties, at least, is sold fresh as orchard-run bulk fruit, being largely purchased at the orchard by wholesale buyers who do their own hauling. This method, though convenient, places the grower at the mercy of the buyer.

APPLE DISTRICTS

As related to the climatic requirements just mentioned, figure 1 shows the relative importance of apple production in the different counties. Two-thirds of the total acreage is to be found in Sonoma County and in the Pajaro Valley in Santa Cruz and Monterey counties. Tuolumne County is credited with a total of 2,500 acres; Mendocino and San Bernardino counties with over 1,400 acres each. Other counties containing small areas but having a total of 250 acres or more are shown in figure 1.

Watsonville District.—The Pajaro Valley or Watsonville area is the oldest and heaviest-producing section in the state, the annual production being between 2½ and 3 million boxes. The C. O. Silliman family orchard was planted in 1853; and commercial plantings began about 1870, be-

coming most extensive between 1880 and 1890, when practically all the alluvial or bottom soils fitted for apples were planted. Subsequent orchards were started on the rolling, residual soils of the valley and in the more hilly parts of Santa Cruz County. In recent years there has

Fig. 1.—Outline map of California showing apple acreage by counties. Data from California Coöperative Crop Reporting Service, 1936.

been relatively little of this activity. Rather, several thousand acres of the older and more unprofitable Yellow Bellflower trees and miscellaneous varieties have been removed and largely replaced by vegetable crops, principally lettuce. Small areas have been planted with pears and apricots.

Approximately 60 per cent of the apple acreage is of the Yellow New-

town variety; 25 to 30 per cent of Yellow Bellflower; and the remaining acreage of mixed varieties, mostly Delicious, White Pearmain, and Winter Banana. Newer plantings have been largely of Delicious.

The soils vary from porous sandy loams to clay loams and clays on the terraces and slopes, and from sandy loams to clays and clay-adobes on the valley floors. With an average annual rainfall of 20 inches or more, comparatively cool temperatures, and high humidity, most orchards are nonirrigated. Some, however, perhaps 20 to 25 per cent—receive one 6 to 8-inch irrigation in July or August, the water being obtained from wells.

Because of the climatic conditions, red varieties may lack high color. Eliminating a small percentage of the poorest-producing orchards, average yields probably are from 400 to 450 packed boxes to the acre; yields from the best orchards, often as much as 1,000 to 1,200 boxes. Crop failures are rare.

The major part of the crop is sold to cash buyers who do their own harvesting and packing. Seasonal contracts are frequently made when the trees are in blossom. The district is well provided with commercial packing houses, cold-storage facilities (sufficient to hold 1,400,000 boxes), evaporators, and by-product plants. Some 5,000 to 7,000 tons of evaporated apples are produced annually.

Although fogs are frequent, fungus diseases are relatively few; apple mildew and the various fungi causing heart rot or wood decay are the most troublesome. Codling moth, aphids, and the leaf roller are the most important insects. Fruit of the Yellow Newtown variety from this section is subject to discoloration discussed under "Internal Browning."

Sonoma County.—Early plantings of apples in Sonoma County were made about 1880; most rapid plantings between 1900 and 1910. Though the total acreage now slightly exceeds that in the Pajaro Valley, the tonnage produced is not so great. Total shipments of packed apples vary from 700 cars or less in occasional years of short crops to 2,000 cars in other years. In most years shipments approximate 1,500 cars. About half of the total production is now dried.

Approximately three-fourths of the apple crop of the county originates in the Sebastopol area, extending about five miles south of Sebastopol, west to Occidental, and north to Forestville and Trenton. The topography there is naturally rolling, the soil being usually a fine sandy loam with a permeable clay subsoil. From the standpoint of climate this region, though coastal, partakes somewhat of inland-valley conditions. Day temperatures are considerably higher than in the Pajaro Valley, while the rainfall is about one-third greater—perhaps 37 inches. Irrigation, though not generally practiced, would doubtless be beneficial, wherever

water is available. Although many varieties are grown, between 65 and 70 per cent of the acreage is devoted to Gravensteins. These, harvested in July, supply the eastern markets with the first boxed apples of the season. The district is well provided with selling organizations, evaporators, and vinegar plants.

Other areas of the county include those adjacent to Geyserville and Healdsburg farther north, the small Annapolis section near the coast, and the Vineburg and Sonoma districts in the southeastern part. Except in the Annapolis section, where summer temperatures are cooler and the season about two weeks later, the general climatic and growing conditions in these districts resemble those of Sebastopol. In the Geyserville and Healdsburg areas, somewhat heavier and also more gravelly soils prevail, and the topography is flatter. Irrigation is available in a few orchards. As in the Sebastopol area proper, the Gravenstein is the principal variety.

Tuolumne County.—Plantings in Tuolumne County are much less extensive and generally in smaller units than in the Watsonville or Sebastopol areas. Nevertheless, with the increase since 1926, bearing acreage in Tuolumne County is now approximately 2,500 acres. The principal plantings are in the Yankee Hill, Soulsbyville, Ralph Station, and Tuolumne districts in the southwestern part of the county at altitudes of 2,300 to 3,500 feet. The general topography is typical of the Sierra Nevada foothills, rolling to hilly, with many of the orchards on rather steep slopes and surrounded by timber (figs. 2 and 3).

The nature and depth of the soil varies with the type of rocks from which it has been derived. Soils obtained from granodiorite are light red in color, sandy loam to loam in nature, well drained, and from shallow to 6 feet in depth. Those from the slates and diabase are somewhat heavier and of a deeper red. All are rather easily cultivated, but such work is often difficult or inadvisable because of the steepness of the slope.

Irrigation water at approximately 25 cents a miner's inch is obtained from the south fork of the Stanislaus river and nearly all orchards receive one or two irrigations annually at a cost of $7 to $12 an acre.

San Bernardino County.—Apple acreage in San Bernardino County, which in 1925 was 6,000 acres, is now only about 25 per cent of this amount. The Yucaipa district on the mesa lands east of Redlands at elevations of 2,000 to 3,000 feet has had the acreage greatly decreased. High cost of water for irrigation and winter temperatures too mild for an adequate dormant period of the trees are the main reasons for the decline. Some of the acreage has been replanted with freestone peaches, and a small amount with oranges and grapefruit. The leading apple

Fig. 2.—General view of Tuolumne County apple section between Sonora and Tuolumne.

Fig. 3.—Hillside apple orchard near Sonora, Tuolumne County, at 3,000 feet elevation.

varieties have been Rome Beauty, Winesap, Delicious, and King David. In the adjoining district of Oak Glen, at elevations of 4,000 to 5,000 feet, climatic conditions—except for late spring frosts—have proved more suitable for apple production; and little change has occurred. Plantings

at Chino in the southwest part of the county have been almost eliminated; likewise those at Adelanto. The apple acreage in the desert districts near Victorville, of which Apple Valley is the most important, has declined approximately 50 per cent. In general, probably apple growing in San Bernardino County will become more and more limited to small local areas in the foothill and mountain districts.

Mendocino County.—Orchards of Mendocino County are somewhat scattered, with the main center of production in the Anderson Valley about midway between Ukiah and the coast. From 4,000 to 5,000 tons are produced annually. The orchards are located on cutover redwood lands, and the trees are grown without irrigation. Jonathan, Baldwin, Rome Beauty, Rhode Island Greening, Gano, King, Ben Davis, Delicious, Winter Banana, and Wagener, as well as many less popular varieties, are grown successfully. Much of the crop is dried by individual growers in their own dehydrating plants. In the last few years, however, approximately 500 tons have been sold direct to fresh-fruit markets, San Francisco and local dealers purchasing the fruit at the orchards and doing their own hauling. Although with proper attention to spraying and other orchard operations, excellent apples can be produced, the total tonnage has not warranted a definite general market for packed fruit.

Besides the districts mentioned above, from 400 to 800 acres of bearing trees are found each in the following counties.

Santa Clara County.—Most of the apple orchards of Santa Clara County are in the San Francisco Bay region, from Mountain View to Milpitas, with a smaller number in the mountain sections. Yellow Newtown, White Pearmain, Smith Cider, Alexander, White Astrachan, and Yellow Bellflower are the leading varieties. At present the acreage is on the decrease, the section being apparently better suited to pears.

San Diego County.—Production in San Diego County is confined to the Encinitas and Escondido districts near the coast, with White Pearmain, Rome Beauty, and Yellow Newtown as the leading varieties, and to the mountain sections around Witch Creek, Santa Ysabel, Warner Springs, Julian, Cuyamaca, and Palomar. Most standard fall and winter varieties are grown in these sections of higher elevations, Delicious being perhaps of greatest importance. Although most of the crop is marketed locally, there are some truck shipments to Los Angeles.

Napa County.—The apple acreage in Napa County runs heavily to Gravensteins, the Carneros section southwest of Napa being the principal district.

Butte County.—Three-quarters of the bearing apple acreage of Butte County is located adjacent to Paradise at elevations of 1,000 to 2,000

feet. Most winter varieties are grown, but Delicious predominates. Approximately 150 acres of apples are located in the Chico-Durham district.

Humboldt County.—Conditions in Humboldt County resemble those in Mendocino, but with orchards even more scattered.

Kern County.—Commercial production in Kern County centers near Tehachapi at altitudes ranging between 3,000 and 4,500 feet. Jonathan, Gano, Arkansas Black, Winesap, Delicious, and Winter Banana are the main varieties. Most of the crop is sold in Los Angeles and Bakersfield. Unfavorable weather conditions at blooming time, blight, lack of water, and absentee ownership have often reduced the profits. Acreage has been materially reduced during the last few years.

Contra Costa County.—Commercial apple production in Contra Costa County is limited to a few orchards in Happy, Reliez, and Alhambra valleys. Yellow Newtown, Spitzenburg (Esopus Spitzenburg), Winter Banana, and Yellow Bellflower are probably the main varieties.

Placer and El Dorado Counties.—Apple orchards in these two counties are scattered throughout the fruit-growing districts at elevations of 2,000 to 3,000 feet. The fruit has been marketed locally. Numerous fall and winter varieties are grown.

Los Angeles County.—Apple production in Los Angeles County has declined markedly during the past decade, most of the acreage being now confined to the Antelope Valley north of the Tehachapi range.

CHOICE OF VARIETIES

Of several thousand named varieties of apples, twelve or fifteen comprise most of the commercial crop of the United States. In California a large proportion of the crop is limited to Yellow Newtown, Gravenstein, and Yellow Bellflower. Some of the less-grown commercial sorts, however, prove, under certain conditions, as profitable as these three—in some instances more so. In fact, more of the recent plantings have been of other standard varieties or their newer strains. The varieties grown primarily for home use are largely a matter of personal preference, but those grown commercially must promise profitable returns. Varieties for a commercial orchard should therefore be chosen after a consideration of the following factors.

Adaptability to the Section.—In districts of commercial importance there are usually several varieties better adapted to the existing climatic and growing conditions and more profitable than others. Since these varieties have been determined by trial, they serve as a valuable guide for future plantings. It does not necessarily follow, however, that additional

plantings of these are to be recommended. Present production may already exceed the demand, or some other condition may make the planting of other sorts more desirable. Watsonville, for example, under coastal conditions where the ordinary red varieties usually fail to color well, has specialized in Yellow Newtown and Yellow Bellflower, both yellow varieties. Though the Yellow Newtown plantings are extensive, the fruit usually lacks the smooth finish of that grown in other districts and often fails to keep well in storage. The crop of Yellow Bellflower is also often larger than can be disposed of profitably. For these reasons it is doubtful whether these varieties should be included in any new planting. Other green or yellow sorts, such as Golden Delicious, Winter Banana, White Pearmain, or some of the newer red strains of Delicious, Jonathan, or Rome Beauty are among those considered most favorable.

The Sebastopol district has specialized in the Gravensteins; but as these are now produced in larger quantity than can be profitable, additional plantings are not recommended. New orchards contain other sorts, primarily red strains and particularly Red Rome Beauty.

At low altitudes in the valleys where high summer temperatures exist, only fast-growing, early-maturing apples are suggested. With late varieties the growth of the fruit is checked somewhat during the middle of the summer; and early dropping, small size, and poor texture generally result. Where strong winds during the late summer often blow a considerable part of the crop from the trees, an effort should be made to secure early-maturing varieties and to avoid those that have a natural tendency to drop.

Variety Characteristics.—Besides this fault of dropping, one should consider vigor of trees and regularity of crops. Weaker-growing varieties, such as Grimes Golden or Wagener, those particularly susceptible to prevalent diseases, and those of irregular bearing habits, as Spitzenburg and Northern Spy, should be avoided unless they have proved profitable despite the higher cost of production. Although quantity may sometimes be sacrificed for quality, in commercial orchards this policy is practical only within certain limits. Good storage qualities are desired in late varieties, while with summer varieties the general time of ripening is important.

Provision for Cross-Pollination.—As pollination experiments have shown, most varieties of apples under California conditions are either unfruitful or unable to set satisfactory crops when self-pollinated. According to Philp and Vansell,[3] solid plantings of Baldwin, Early Har-

[3] Philp, G. L., and G. H. Vansell. Pollination of deciduous fruits by bees. California Agr. Ext. Cir. 62:1–27. 1932.

vest, Grimes Golden, Oldenburg, Wagener, Wealthy, Yellow Newtown, and Yellow Transparent will usually set commercial crops. Cross-pollination, however, has generally resulted in larger yields. Ben Davis, Gano, Jonathan, Spitzenburg, Rome Beauty, Tompkins King, and York Imperial may be self-fruitful in some years. Other varieties, including Yellow Bellflower, Gravenstein, Delicious, McIntosh, Winesap, Stayman Winesap, White Pearmain, and Winter Banana, are usually self-unfruitful and should definitely be interplanted with some other variety for cross-pollination. Apples of the Winesap group, including Winesap, Stayman Winesap, Arkansas, and Arkansas Black, appear to be unfruitful even when interplanted.

Except for these apparent cases of unfruitfulness between varieties, one need consider only the season of blossoming and sometimes the relative amount of pollen produced. Summer varieties usually bloom somewhat earlier than fall or winter varieties. Winesap, Stayman Winesap, and Gravenstein are rather poor pollen producers and are undesirable as pollinizers of other varieties. As Delicious usually produces abundant pollen, this variety or Yellow Newtown is recommended for pollinating Gravenstein.

Market Demands.—Although home orchards may cater to one's personal taste, commercial orchards should contain only varieties of recognized importance for which a good demand exists. The average retail buyer of apples for dessert or cooking has a very limited knowledge of varieties and usually confines his purchases to those with which he is familiar or else to some variety particularly attractive in appearance. If the latter fulfills his expectations as to quality, a demand will soon develop. Delicious, easily recognized by the prominent knobbing around the blossom end, quickly gained a reputation and has risen to prominence because of its pleasant flavor. The flesh, however, quickly becomes overripe; and the variety is of little value for cooking.

Besides the original Delicious, both red and yellow strains of this variety are now gaining in popularity for eating fresh. For baking purposes the large size, smooth shape, and good culinary qualities of the Rome Beauty make it the leading variety. The superior storage qualities of Winesap and Yellow Newtown make these prominent late commercial varieties.

Such examples show that each commercial variety grown should fill some definite market demand—preferably better than most other competing varieties. Since, however, the demand for any particular variety is limited, excess planting will result disastrously. Under certain circumstances a limited quantity of some inferior variety ready for mar-

keting at just the right time may prove more profitable than some better variety that has been overplanted.

Previously little attention has been given to varieties for drying; almost any sort unsuitable to be sold profitably as fresh fruit went to the dehydrators. Many miscellaneous varieties will continue to be utilized thus; but with a demand for a better and more attractive dried product, those varieties giving the largest yield per ton of fruit dried and those drying with the best color and quality will prove most profitable. Yellow Newtown and Rhode Island Greening probably have preference over other California varieties. Gravenstein and Yellow Bellflower are also popular. (See discussion of drying.)

DESCRIPTION OF VARIETIES

The following descriptions include the most important commercial varieties of the state and several considered valuable for home use. They are listed in their approximate order of ripening, although there will be considerable variation in this respect, according to the section. The season given after each variety represents the period of greatest use. The illustrations shown (plates 1–4) are approximately half size.

Yellow Transparent.—Origin, Russia. An important early variety in the eastern states; little grown in California. Fruit of good size, roundish conic, attractive greenish to whitish yellow; skin thin; flesh white, moderately fine-grained, tender, sprightly subacid; excellent for cooking purposes. Defects: fruit easily bruised; tree subject to blight, though moderately vigorous. Suggested for trial as an early yellow apple under valley conditions. Season, June 15 to July 15.

Red Astrachan.—Origin, Russia. The variety is widely known and is recommended for early home use and for local markets. Fruit is of medium size, rather irregularly shaped, usually roundish to slightly flattened; skin thin and tender, greenish yellow to striped or deep red, covered with a pale, bluish bloom. Flesh white, juicy, crisp, of good quality for both dessert and cooking. Tree hardy, vigorous, an early and regular bearer. Principal defects: fruit not uniform in size, often small, inclined to drop, not a good shipper. Season, July.

White Astrachan.—Origin, Russia. Well adapted to most parts of the state and recommended for commercial planting as a summer variety in the Sacramento and San Joaquin valleys. Fruit large to very large, almost round, flattened at each end; skin greenish white, with faint streaks of red, and covered with white bloom. Flesh white, juicy, crisp, somewhat coarse and acid; primarily a cooking variety. Tree large, vigorous, productive. One of the best early varieties for local market.

Fruit too easily bruised to be shipped long distances. Season, July and August.

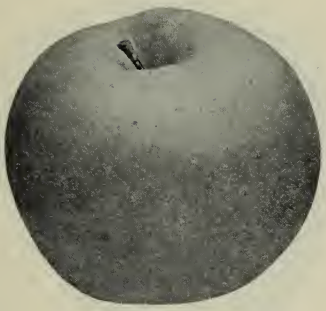
Gravenstein.—Origin, probably Germany. The most popular and most extensively grown summer apple in California. About 1,500 carloads annually (the best of the crop) are packed and shipped to eastern fruit markets as early boxed eating apples. Fruit medium to large, slightly flattened, broad at the stem end, a little one-sided or angular. Stem short, deeply set in the cavity. Skin greenish yellow to orange yellow overlaid with broken stripes of light and dark red. Flesh tender, crisp, highly aromatic. Of very good to best quality both as a summer dessert and as a cooking apple. Trees usually large and vigorous, coming into bearing rather early and producing good crops. Chief defects: tendency to drop badly; high percentage of windfalls; susceptibility to bitter pit; necessity of several pickings because of irregular size and coloring; difficulty of removing one specimen from a cluster without the others dropping.

A good variety for both commercial and home use. Season in Sonoma County, July and August. Some interest is now being manifested in the red bud sports of this variety, which are of practically solid red color. One of these has been named Banks.

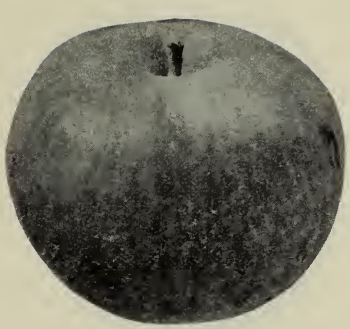
Alexander.—Origin, Russia. Rather widely distributed in the United States but of limited planting in California. One of the most important summer varieties in Santa Clara and Napa counties. Fruit large, roundish conic to slightly oblate conic; red or striped. Flesh white to slightly yellow, rather coarse, but of fair quality for cooking. Common defects: cracking of the skin and flesh around the stem; premature dropping. Continuous ripening over a period of several weeks. Trees vigorous, but not always good bearers. Season, July and August.

McIntosh.—Origin, Canada. Excellent for home use; well adapted to local markets. Not recommended for commercial planting because of tender flesh, susceptibility to apple scab, tendency to drop prematurely. Fruit medium and uniform in size, roundish to roundish oblate; regular or faintly ribbed. Skin thin, smooth, tender, readily separated from the flesh. Color bright red, striped with carmine to dark purplish red with stripes obscure, overspread with thin lilac bloom. Flesh very tender, usually snow white, fine-grained, crisp, tender, very aromatic. Flavor mild subacid to sweet. Quality very good to best. Season, September and October.

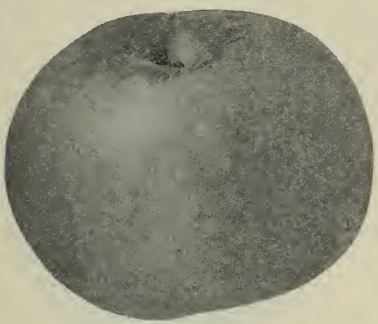
Rhode Island Greening.—Origin, probably Rhode Island. Often found among the older orchards in the coast counties. Popular for drying because of heavy yields of dried fruit, but never grown extensively in California. Fruit medium to large, roundish oblate, dark green to green-



a. Yellow Transparent



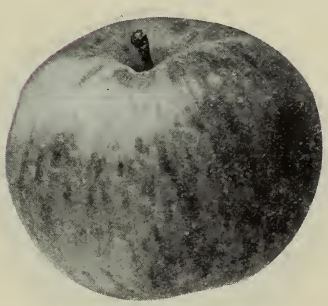
b. Red Astrachan



c. White Astrachan

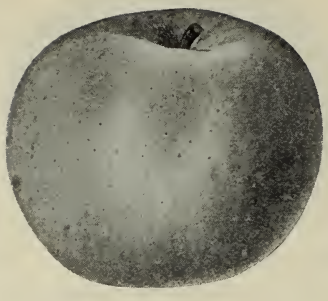
d. Gravenstein

e. Alexander



f. McIntosh

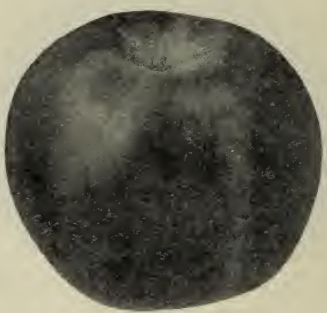
PLATE 1.—APPLE VARIETIES



a. Rhode Island Greening

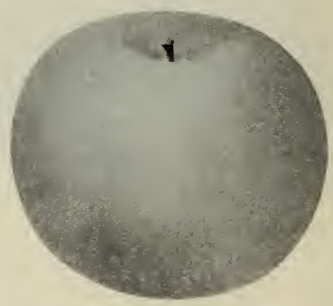
b. Yellow Bellflower

c. Jonathan



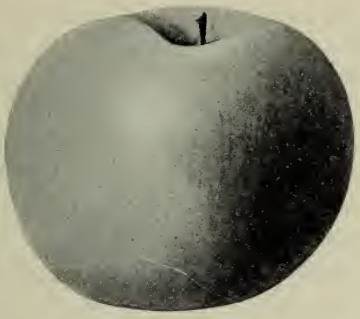
d. King David

e. Tompkins King



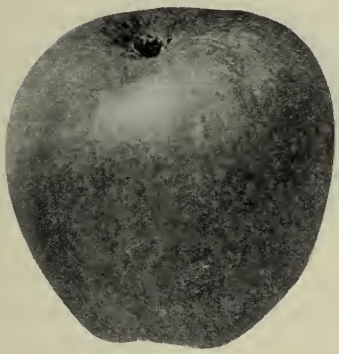
f. Grimes

PLATE 2.—APPLE VARIETIES



a. Winter Banana

b. Delicious



c. White Pearmain

d. Wagener

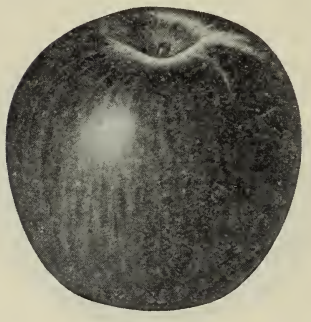
e. Baldwin

f. Esopus (Spitzenburg)

PLATE 3.—APPLE VARIETIES

a. Stayman Winesap

b. Rome Beauty



c. Winesap

d. Gano

e. Yellow Newtown

f. Arkansas Black

PLATE 4.—APPLE VARIETIES

ish yellow. Flesh yellow, fine grained, tender, juicy, sprightly subacid. Quality very good. Season, fall and early winter.

Yellow Bellflower.—Origin, New Jersey. One of the best-known early fall market varieties grown in the state—in the Pajaro Valley, second only to Yellow Newtown. Fruit large, oblong, ribbed, and tapering toward the blossom end. Skin lemon-colored to yellow, marked with prominent dots and with a pink blush on the exposed cheek. Flesh nearly white, tender, juicy, and crisp, with subacid flavor. Quality not high, but a good fall variety for general use. Tree a strong grower and good producer. Fruit variable in size and quality, requiring careful handling. Prices usually lower than for later varieties. Season, September to November.

Jonathan.—Origin, New York. A seedling of the Spitzenburg and in numerous respects not dissimilar. Important in San Bernardino, San Diego, Mendocino, Humboldt, and Sonoma counties. Usually successful where fall and winter apples are grown. Similar to Spitzenburg in shape and color but without the conspicuous dots on the skin. Flesh light yellow, tender, juicy, sprightly subacid, of excellent quality for all purposes. A good storage variety for a fall apple. Tree vigorous under good conditions, early-bearing, a good producer. Season, September to January.

Where Jonathan fails to attain a solid red color, planting of the red strains is suggested. One of these listed by nurserymen is given the trade name of Blackjon.

King David.—Origin, Arkansas. A very rich-red apple about the size of the Jonathan and somewhat similar; not of so high dessert quality, but a very attractive market variety, planted to a considerable extent for the fall trade. Fruit of medium size, roundish conic, usually deep solid red. Flesh yellow, firm, crisp, moderately tender, of good quality. Season, September to December.

Tompkins King.—Origin, New York. Secondary in commercial importance, grown in mountain sections, popular in Humboldt and Mendocino counties. Fruit large, round or globular, angular or ribbed, yellowish, shaded with red and striped and splashed with bright carmine; dots numerous and conspicuous. Flesh yellowish, moderately coarse, rich, juicy, tender. Mild subacid flavor; very good quality. Season, September to October.

Grimes.—Origin, West Virginia. Better known as Grimes Golden. Highly esteemed as both a dessert and a culinary apple but grown to only a limited extent. Defects: necessity for careful handling; tendency of trees to make a weak growth and produce light crops. Excellent for

home use wherever produced successfully. Fruit clear, rich yellow; medium to large; roundish oblong; often flattened or truncated at the ends. Basin or depression at blossom end abrupt, deep, moderately wide. Skin tough, covered with light russet dots. Flesh yellow, firm, tender, crisp. Flavor mildly subacid, rich, aromatic. Quality excellent. Season, fall and early winter.

Winter Banana.—Origin, Indiana. If well grown, one of the most beautiful varieties. Fruit large, shapely, pale waxed yellow, with a decided pink or sometimes red cheek. Usually characterized by a distinct suture line on one side extending from the basin to the cavity. Flesh pale yellow, crisp, tender, mildly subacid, of a distinct musky fragrance. Quality very good. Very easily bruised; not well suited for commercial handling. Grown in both foothill and coastal sections. Season, October to November.

Delicious.—Origin, Iowa. As a dessert apple, widely and favorably known. Found in most apple sections; planting gradually being extended. Fruit very characteristic in shape, usually decidedly tapering, somewhat irregular, with five very prominent knoblike protrusions at the blossom end. Dull, dark red color, if well grown. Flesh white, fine grained, very mildly acid, aromatic, of delightful flavor and excellent dessert quality. A general favorite on the fruit stands; always sold at a premium. Tree one of the strongest and most vigorous growers, aphid-resistant, blooms late, and is a good pollinizer. Defects: poor flavor unless well colored; failure to cook well; tendency to drop and under ordinary temperatures to become mealy. Season, October to January.

Because of the lack of color, wide interest is now being shown in the red bud sports of this variety. These may be offered by nurserymen simply as Red Delicious or under such trade names as Richared Delicious or Starking Delicious. The only essential difference between these sports and the original Delicious is in color.

Golden Delicious.—Origin, West Virginia; discovered as a chance seedling about 1890 and introduced by Stark Bros. of Louisiana, Missouri, in 1916. Already important as a yellow apple of high dessert quality. Of separate origin and unrelated to the original Delicious. Fruit clear yellow, with small conspicuous russet dots about the stem end. Medium to large, oblong conic, smooth to somewhat ribbed, with a deep acuminate cavity and a rather long slender stem. More uniform and regular in shape than Yellow Bellflower; longer and more conic than Grimes Golden. Flesh is greenish cream in color, firm, crisp, fine-grained, tender, juicy, aromatic, mildly subacid. Also reported to be good for culinary purposes and for storage. Season, October to February.

White Pearmain.—Origin, uncertain. An old favorite variety of high quality, adapted primarily for home use and local trade. Rather widely adapted, but grown in California primarily in sections having coastal influences where red sorts do not color well. Trees vigorous; regular bearers. Fruit medium to large, oblong conic, pale greenish, often with a decided blush on the exposed cheek. Surface of the skin covered with numerous small brown dots. Flesh yellowish, tender, crisp, juicy, very mildly subacid, of excellent flavor, somewhat resembling Delicious. Season, October to January.

Wagener.—Origin, New York. Relatively unimportant in the state, but often found in Mendocino, Humboldt, Napa, and Sonoma counties. Under favorable conditions, an excellent fall and early winter variety, but not one of good keeping or shipping quality. Trees small, upright in habit of growth, coming into bearing early. Only moderately vigorous, but usually productive of good crops. Fruit of medium size, characterized primarily by its flat or oblate shape and by broad ribbing from stem to blossom end. Skin bright pinkish red, striped with darker red and often streaked with a thin, whitish covering. Flesh whitish, moderately firm, fine-grained, tender, crisp, and juicy. Flavor sprightly subacid. Quality very good to excellent. Season, October to December.

Baldwin.—Origin, Massachusetts. The variety that formerly constituted about half the commercial crops of New York and the New England states. In California, found only in small plantings in the northern coast counties and in elevated regions. In certain sections, well adapted and grown to a high degree of perfection; in others, unsatisfactory in color. Fruit (when well grown) large, roundish conic; deep, bright red, with a few rather distinct dots. Flesh yellowish-white, crisp, juicy, tender, and mildly subacid. Quality very good and adapted for general market, dessert, and cooking. Season, October to December.

Esopus Spitzenburg.—Origin, New York. Usually known simply as Spitzenburg. An almost unexcelled market variety, of high quality for dessert and cooking. Fruit of good size, uniformly shaped, varying from oblong to conic. Skin smooth, covered with rich red and marked with numerous conspicuous yellowish dots. Flesh yellowish, firm, crisp, tender, juicy, sprightly subacid. One of the most attractive varieties grown. Costly to produce, planting therefore generally on the decline. Defects: tendency toward shy and irregular bearing; susceptibility (despite general healthiness) to apple scab, aphids, and (in some sections) blight; long, polelike branches, somewhat difficult to control in pruning; planting in California therefore limited. Season, November to February.

Stayman Winesap.—Origin, Kansas. Successful in the foothills,

mountain valleys, and at points of higher altitudes in the interior valleys. In many respects similar to its parent, the Winesap; unlike it in possessing less color but growing to larger size. Flesh more tender than Winesap, requiring careful handling, keeping quality poorer. Characterized as medium to large, round conic, with smooth, thick skin covered with dull red and marked with light gray and russet dots. Flesh yellow, fine-grained, very tender, crisp, juicy, pleasantly subacid. Dessert quality very good. Defects: failure to color properly in certain sections; tendency to drop when mature; necessity of careful handling; susceptibility to scald in cold storage. Season, November to December.

Blaxtayman and Staymared, two bud sports of Stayman Winesap, have somewhat more red color.

Rome Beauty.—Origin, Ohio. One of the leading commercial apples of the country, with an established reputation in all markets. Not of high dessert quality, but especially attractive for baking. Good for handling and shipping. Because of its late blooming habit, recommended for higher altitudes, especially where late spring frosts make growing of other varieties precarious. Trees of only medium size but, under good conditions, vigorous and early-bearing, and producing uniform crops. Defects: fruit borne especially on the ends of branches, which may whip badly in high winds; variety rather subject to attacks of aphids. Fruit uniformly large, smooth round to round conic; skin thick, smooth, yellow, shaded and striped with bright red to solid red on the exposed cheek, sprinkled with conspicuous yellow dots. Stem set in a very broad, shallow, usually green cavity. Flesh yellow, firm, crisp, mildly subacid, quality fair. Season, October to February.

Rome Beauty is another variety having one or more red bud sports, essentially the same apple as the parent except that the fruit is mostly of solid red color.

Winesap.—Origin unknown. One of the oldest and most cosmopolitan sorts, a general market favorite as a late winter variety. Grown in almost every apple section of the country. In California, adapted to most sections other than those exposed to coastal conditions and those of the hot interior valleys. Excellent in foothills and mountain sections. Trees vigorous, productive. Tendency for old trees to overbear and produce small fruit, necessitating thinning of the crop. Fruit of medium size, roundish to conical; skin tough, smooth, bright to dark red, with small scattering dots. Flesh yellow, firm, crisp, sprightly subacid. Good to very good quality for both dessert and cooking. Season, November to April.

Gano.—Origin uncertain, probably Missouri or Tennessee. Often called Black Ben Davis; similar if not identical to Ben Davis except in

color. Not largely grown in California except for a considerable acreage in different districts of higher altitudes. Low in dessert quality but excellent for shipping; one of the best-keeping sorts. Trees similar to Ben Davis, growing rapidly, bearing early, regularly, and abundantly. Fruit medium to large; roundish conic; regular, symmetrical, and uniform in size and shape. Skin smooth, waxy, light yellow, but mostly overlaid with pinkish to dark-purplish red, more or less obscurely striped; prevailing color red. Dots numerous, small, inconspicuous. Flesh white to slightly yellow, firm, rather coarse, mildly subacid. Season, November to February or later.

Yellow Newtown.—Origin, New York. Easily the first commercial winter variety grown in the state, over 1½ million boxes being shipped annually from the Pajaro Valley. Commercial production confined almost entirely to that section. Defects: a russeting of the skin under Pajaro Valley climatic conditions, detracting somewhat from the general appearance; susceptibility to browning around the core in storage. Trees rather slow-growing but productive and reasonably early-bearing. Excellent for late winter use and probably the most desirable California variety for drying. Fruit large, roundish to slightly flat. Skin green to yellow, often with brownish red cheeks. Flesh cream, firm, crisp, juicy, very good in quality. Season, December to May.

Arkansas Black.—Origin, Arkansas. Often confused with Arkansas or Mammoth Black Twig. Grown in California to only a limited extent. Suggested by nurserymen as suitable for interior section. Of some commercial importance in Butte County. Fruit roundish and uniform, of a very attractive dark color. Skin decidedly "waxy" or "oily" to the touch. Flesh a deep cream, very firm, moderately fine-grained, crisp, moderately juicy. Of good flavor, excellent for storage, but not an apple of high quality. Time of ripening, late fall.

Crab Apples.[4]—Of comparatively small commercial importance, but highly regarded for jelly making and preserving. Grown for home use and for a limited demand on local markets. Most important varieties: Whitney, Transcendent, Hyslop, Montreal Beauty, Large Red Siberian. Of these the first three are perhaps in greatest demand commercially. Red Siberian is reported as being successfully grown in most parts of the state.

[4] For detailed descriptions of crab-apple varieties see:

Beach, S. A. Apples of New York. Vol. 1. p. 251–69. Illustrated. New York State Dept. Agr., Albany, N. Y. 1905.

Wickson, E. J. California fruits. 10th ed. p. 215. Pacific Rural Press, San Francisco, Calif. 1926.

Hedrick, U. P. Cyclopedia of hardy fruits. p. 72–76. The Macmillan Co., New York, N. Y. 1922.

SECURING AND CARING FOR NURSERY TREES

Since cultivated varieties of fruit trees rarely come true to type when propagated from seed, seeds are used only to produce nursery seedlings upon which the desired varieties are budded or grafted. To produce nursery stock successfully requires time, patience, and a certain skill obtained only by experience. Apple growers therefore usually purchase from a nurseryman. In some instances, however, individual growers wish to produce their own trees. They may desire additional specimens of some particular variation, some unknown variety, or some general favorite no longer commercially propagated.

Bud or Scion Wood.—If the trees are to be propagated by budding, bud sticks of the present season's growth may be collected, at the time needed, from the variety or particular tree to be propagated. With apples, budding is usually done from July to September or at least as long as the bark of the stock will slip. Where propagation is by grafting, scions of the past season's growth are collected while dormant and are either used immediately or stored in a moist, cool place until desired. Root or bench grafting is usually employed, being done indoors at any time during the winter season, and the grafts held in moist sand or sphagnum moss until ready for planting. Scion wood the approximate diameter of a lead pencil is usually preferable to that which is smaller.[5]

Where one has space for only a tree or two and wishes a number of varieties, two or more kinds may be budded on an individual stock. Some nurserymen are now offering apple trees where each of the three to five main branches have been budded or grafted to a separate variety.

Rootstocks.—Unlike most other deciduous fruits, which may be grown upon the rootstock of an entirely different fruit, the apple is limited to the apple root. Even unions with its near relative, the pear, are not successful. Individuals wishing to propagate their own trees may either purchase the necessary apple seedlings to be used as stocks or may grow these from seed obtained from dehydrators or by-products plants.

Previously, nurserymen produced most of their trees on "French crab" stock, the seed presumably coming from the native seedlings of France. In recent years, however, because of inability to secure this seed in sufficient quantities or in time for fall planting, most apple stock is now produced from the seed of our own cultivated varieties. The consensus of opinion is that these produce stock just as satisfactory as the imported seed.

[5] For detailed description and illustrated methods of handling seeds, budding, and grafting see: Hansen, C. J., and E. R. Eggers. Propagation of fruit plants. California Agr. Ext. Cir. 96:1–52. 1936.

Most California nurserymen purchase their rootstocks from nurseries in the northwest who specialize in growing stocks. Washington nurserymen report[6] Delicious, Winesap, Rome Beauty, and Stayman Winesap seed as producing excellent rootstocks. Although some use Jonathan, others feel this variety is not satisfactory. Yellow Newtown seed is also used by some Oregon nurserymen. Seed of these varieties is secured in quantity at reasonable cost from apple-processing plants. Nurserymen who do not wish to use the Jonathan seed largely eliminate it by waiting until most apples of this variety have been utilized. Aside from this no other attempt is made to segregate different commercial varieties.

Besides Rome Beauty, Delicious, and Jonathan, the New York Agricultural Experiment Station has also found Wealthy, Ben Davis, and Whitney seed well adapted for rootstocks. Gravenstein, Baldwin, and Rhode Island Greening were less satisfactory. Certain types of Paradise rootstock are used where dwarf trees are desired.

Age and Grade of Nursery Trees.—Good commercially propagated trees may be purchased from any reliable nurseryman. The trees in greatest demand for planting are those with one-year-old tops. Because the two-year-old tree receives greater injury to its roots when being transplanted, perhaps it does not come into bearing earlier than the one-year-old. The latter also usually possesses enough good buds on the stem to form scaffold branches where desired.

Formerly nursery trees were graded only according to height, but now the leading nurserymen consider also the diameter of the main stem and usually grade or classify one-year-old trees into the following groups:

4–6 feet high, ½ inch or over in diameter.
3–4 feet high, ⅜ to ½ inch in diameter.
2–3 feet high, ¼ to ⅜ inch in diameter.

The price naturally varies with the size and grade. It is doubtful whether the smallest sizes should be purchased if one can secure those that have made a better growth. Regardless of age or size, the main stem of the tree should be reasonably stocky, the bark clean and smooth, and the top well supplied with good buds or well-spaced branches. It should also possess a good union where the bud or the scion was inserted into the stock. If this union has not grown together properly, various fungus troubles are likely to enter at this point and shorten the life of the tree, or it may break off several years after being planted in the orchard.

Trees from a nursery should be ordered well in advance so that the desired varieties may be secured.

[6] Personal correspondence.

Care of Nursery Trees.—The trees, when received, should be removed from the original package and, unless planted immediately, should be heeled-in at some convenient place, preferably one not exposed to the afternoon sun. Where trees ordered from a distance arrive in a dry condition, the roots may be soaked in water for several hours before heeling-in. If the branches also appear dry, the entire tree may be put in the soil and covered for several days.

ESTABLISHING THE ORCHARD

Preparing the Land.—Proper preparation of the land before planting gives the trees a more satisfactory start; their growth the first season often determines their future productivity and profitableness.

Though the orchards in the larger apple sections of the state are on land cleared and cultivated for a good many years, some new plantings are on virgin soil.

Where the land was formerly devoted to grain crops one should plow several inches deeper than before in order to break up any plow sole. In some instances subsoiling in the tree rows may be desirable. This should always be done in the fall before planting. Except on steep slopes, where washing may occur, the land may also be plowed in the fall. Fall-plowed land, left rough, will absorb the maximum amount of moisture during the winter and may be planted earlier in the spring. Thorough disking and harrowing usually suffice to put the soil in good friable condition.

Land long cultivated or devoted to grain crops is apt to be deficient in organic matter. Such soils may well receive, the fall before planting, an application of barnyard manure, 15 to 20 tons to the acre; or the land may be sown to some green-manure crop that can be turned under the following spring. The latter practice is growing in importance as animal manures are becoming more difficult to secure.

In the smaller apple sections, particularly at considerable altitudes, much of the land is more or less heavily timbered, so that considerable work is necessary to prepare it for planting. In some instances the method followed is only to cut and remove the timber, dig the holes, and plant the trees among the stumps. Although some of these trees, because of the very fertile soil, have made good growth, subsequent plowing and cultivation are difficult. Unless the stumps are of a wood that decays so rapidly as to be out of the way after a few seasons, the most economical plan is to dispose of them at once. Oak and redwood stumps are very slow to decay.

Although most California apple orchards depend upon natural rainfall for their moisture supply, many probably would have been much

benefited had the land been graded and irrigation facilities provided. Leveling for orchards consists mostly in cutting off the high points and depositing the soil in low places. The slope of the land as a whole is usually made as uniform as possible. The system of irrigation used should be adapted to the slope and the amount of water available.

Laying Out the Orchard.—To properly lay out an orchard requires considerable care. Mistakes difficult or impossible to correct can often be prevented by first carefully mapping the proposed orchard on paper, spacing the trees according to scale at the distances decided upon, locating roadways and possible irrigation ditches. Such a map enables one to see how many trees of a given variety are needed and how they may be spaced to the best advantage. If properly labeled and preserved, it is also a ready reference as to the location of any given tree.

Of the different systems of planting, the square is the most popular and convenient, except on very rolling land, where contour planting is recommended. The quincunx system—in reality the square method with a tree in the center of each square—is adopted where the orchard is interplanted with temporary or filler trees.

Planting the trees too close together has been a general mistake in most of the early orchards, many trees having been set 20 to 24 feet apart. These are now crowding badly and need severe pruning, and the fruit is difficult to harvest.

The distance of planting apple trees varies somewhat with the variety and soil conditions. The larger and more spreading varieties such as Gravenstein, Jonathan, and Winesap should be planted at somewhat greater distances than the upright-growing sorts such as the Red June and Rome Beauty. Deep loam or clay loam soils will produce larger trees than the lighter soils. The planting distance may also vary somewhat with the severity of pruning. Usual planting distances recommended for the apple on good fertile soils are 30 to 35 feet.[7]

Planting.—Where the soil has previously been well prepared the holes for the tree need not be larger or deeper than is necessary to accommodate the roots in their natural position.

Setting the tree at the proper depth and compacting the soil well around the roots are important considerations. Nursery trees usually form their roots at a depth most congenial for their development and when set in the orchard should stand at approximately the same depth as in the nursery. This depth can generally be determined from the appearance of the tree trunk.

[7] For a fuller discussion of planting distances and methods of thinning see: Allen, F. W. Planting and thinning distances for deciduous fruit trees. California Agr. Exp. Sta. Bul. 414:1–29. 1926. (Out of print.)

To avoid air pockets, well-pulverized soil should be placed next to the tree roots and tramped thoroughly as it is thrown in. All injured roots had best be removed before setting. To facilitate planting, the remainder may be shortened back to 6 or 8 inches. Cutting back is considered preferable to bending out of their natural position. Small, fibrous roots, usually dead before the tree is set, may likewise be removed, for they make it difficult to place the soil in firm contact with the larger roots.

As the newly transplanted tree requires some time to become established and as new root growth should precede that of the branches, trees may profitably be planted as early in the season as mature nursery stock can be secured and the soil can be put in good condition. Where conditions are favorable in late November and in December, trees set at this time should have considerable advantage over those not planted until March or April. At some of the higher altitudes, however, planting must often be delayed until relatively late. Under such circumstances the trees should be held as nearly dormant as possible so that the buds may not push and utilize all the stored food before the growth of the roots.

As many of the feeding roots are cut in digging from the nursery, the top of the tree should be correspondingly reduced. At the time of planting, therefore, the main stem is usually cut back to a height desired for the scaffold branches. Immediately after planting, the entire stem should be protected from sunburn and borers with a coat of whitewash. A good whitewash may be made as follows: quicklime, 5 pounds; salt, ½ pound; sulfur, ¼ pound. Add the salt and sulfur while the lime is slaking. Allow the whitewash to age several days before use, and dilute to a buttermilk consistency. A whitewash that sticks somewhat better but is more expensive is made from whiting, 6 pounds; casein spreader, 1 pound; and raw linseed oil, ⅓ pint.

Subsequent Care of Young Trees.—As previously mentioned, young trees should get a good start and be kept growing vigorously during the first season. Weed growth around the trunk should not compete with the young tree for soil moisture unless there is frequent irrigation. If tree protectors are used instead of whitewash against sunburn, the young trees should be inspected several times to see that these do not interfere with the formation of the scaffold branches at the desired locations. After the new growth starts, better spacing and growth of the main shoots may be obtained by selecting these in the most desirable locations and removing or pinching back the others. (See section on pruning.) In addition, the tree should be kept free from all diseases and insect pests that may interfere with its normal growth.

CULTURAL OPERATIONS IN THE ORCHARD

Cultivation.—As recent experiments have shown, the frequent and deep tillage of most western apple orchards does not seem justifiable; and the claim that intensive cultivation conserves soil moisture, aids soil aeration in the root zone, and increases yields is erroneous. Cultivation has therefore become less frequent and shallower.

Some cultivation, however, is recommended in most orchards: "It serves to remove noxious weeds and weed competition; to facilitate subsequent operations such as irrigation, harvesting, brush removal, and spraying; to incorporate covercrops and manures; to prepare the soil as a seed bed for covercrops; to facilitate the control of certain pests; and to aid in the absorption of water where tillage or other orchard operations have produced an air-impervious condition of the soil."[8]

Except on steep slopes in the foothill and mountain sections where danger of soil erosion demands that the orchards remain in sod, most apple orchards of California are maintained under a system of clean cultivation or of cultivation and covercrops.

The exact time of the first spring cultivation depends upon the condition of the soil, the amount and season of rainfall or irrigation, and the amount of covercrop and weed growth present. Tillage of wet soil is never desirable. The surface should be relatively dry. Many of the heavier apple soils must be worked at just the right time; tilling either too wet or too dry results in a hard, lumpy soil, often for the remainder of the season.

In nonirrigated orchards grown under limited rainfall, the covercrop should be disked down or turned under before the soil moisture is reduced to a point where the covercrop is competing with the trees. With late spring rains or in irrigated orchards, this operation may be delayed somewhat longer, and a heavier covercrop growth secured.

Shallow disking (fig. 4) is not only less expensive than deeper plowing, but preferable. Disking in both directions of the tree rows in the spring should be sufficient to kill the covercrop or weed growth and to incorporate most of it into the soil. Since cultivation in the absence of weeds has no influence in conserving soil moisture, the frequency of subsequent tillage during the summer will depend largely upon the amount of weed growth and the frequency of irrigations or of late spring rains. If rains occur and the soil has become too compact to permit the construction of irrigation furrows or levees (in orchards which are irrigated)

[8] Veihmeyer, F. J., and A. H. Hendrickson. Essentials of irrigation and cultivation of orchards. California Agr. Ext. Cir. 50:1–24. Rev. ed. 1936.

or if there is a resumption of heavy weed growth, a second cultivation may be necessary before irrigating. But as a rule this is unnecessary; hence the second cultivation follows any irrigation given, or it may even be withheld until the irrigation levees must be broken down to facilitate harvesting, spraying, pruning, and brush removal or until a seed bed must be prepared for sowing the covercrop.

Intercropping.—Intercropping is a possible source of income to the orchardist during the first few years. This practice, however, after the

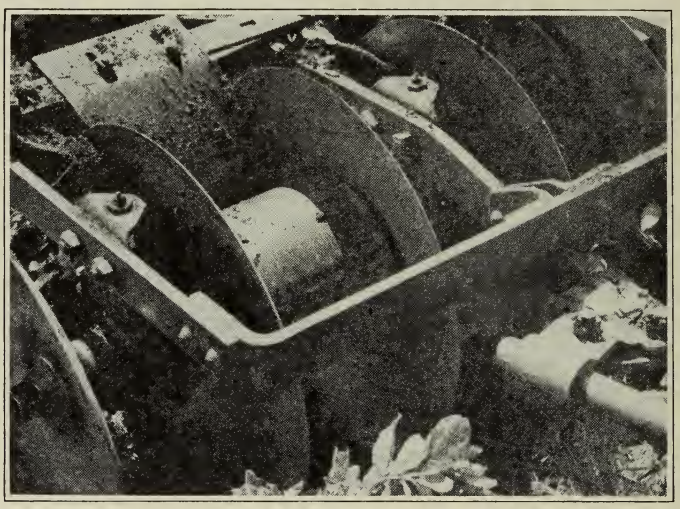


Fig. 4.—Section of orchard disk equipped with depth regulators. The soil is cultivated to a depth of only 4 inches when the disks are set for a full cut.

first two or three seasons really becomes double cropping, in that soil fertility and moisture removed by the intercrop are, in some instances, needed for the best growth of the trees. As a rule, intercrops are most successful on fertile soils and on land under irrigation.

Cultivated crops are recommended for young orchards, and annual crops are considered somewhat more desirable than perennial. Among the most desirable, where a market is established, are beans, squash, melons, cabbage, turnips, mangels, potatoes, spinach, beets, peas, tomatoes, and rhubarb. Lettuce is perhaps now the leading intercrop for any young plantings in the Pajaro Valley. Strawberries are also grown. Bush fruits were previously very popular in the Sebastopol area. Since nursery stock, corn, and other grains compete with the trees more than do other crops, their growth is to be discouraged.

Covercrops.—A covercrop offers the most feasible means of maintain-

ing the organic matter in the soil, and either a seeded crop or one of natural growth is to be found during the winter season in most cultivated apple orchards. The amount of growth secured from covercrops depends upon the soil, the water supply, and the temperature during the growing season. In Sonoma County a satisfactory natural growth of white and red-stem filaree (*Erodium maschatum* and *Erodium cicutarium*), mustard, bur clover, and miner's lettuce usually results from the fall application of manures. Little seeding of covercrops is done. In the Pajaro Valley there are both natural covercrops and those which are sown. As in Sonoma County, manure, applied in the fall, or commercial fertilizer increases growth. To obtain a good growth before the end of the growing season, covercrops may be sown in irrigated sections in August. In nonirrigated sections, little if any advantage is gained by seeding before the fall rains begin. Drilling in the seed is preferred to broadcasting, as the depth of the planting can thus be regulated and a more even stand secured. Although they may vary slightly in different sections, the following rates of seeding are recommended: field peas, per acre, 60–80 pounds; vetch and horse beans, 40–50 pounds; melilotus, 25 pounds, or if scarified, 15 pounds; bur clover and cereals (where planted with legumes), 20 pounds; cereals planted alone, 50–60 pounds.

Either leguminous or nonleguminous crops may be planted, but where the former make satisfactory growth they have the advantage of adding nitrogen to such soils as need it. Among the leading legume crops grown in California are the common vetch (*Vicia sativa*), purple vetch (*Vicia atropurpurea*), bitter clover (*Melilotus indica*), Canada field peas (*Pisum arvense*), bur clover (*Medicago hispida*), and horse bean (*Vicia faba*). As covercrops in apple orchards, the vetches and clovers are usually the most widely grown. Vetch is recommended in the coast counties and south of the Tehachapi. Bur clover does well in most parts of the state, usually reseeding itself year after year if soil fertility is maintained. As a rule, however, it fails to produce such heavy growth as the vetches or bitter clover. The grains—barley, rye, and oats—and the mustards are the most commonly grown nonleguminous plants. The cultivated mustard (*Brassica alba*) is popular in the Watsonville district (fig. 5).

When one has unlimited irrigation facilities and a soil sufficiently rich in available nitrogen to grow two crops simultaneously, summer crops such as cowpeas, soybeans, sweet clover, and its variety, Hubam clover, are sometimes grown. Red clover also seems adapted to the foothills of the Sacramento Valley and may become fairly important in the northwestern coast counties. Alfalfa is a permanent crop, now generally

used in the irrigated apple sections of Washington and Oregon and grown to a limited extent in this state.

As stated under the section on cultivation, unless the covercrop is becoming excessively heavy, it should be allowed to grow as late in the spring as is consistent with maintaining good soil moisture.

With a supply of irrigation water, the crop can both be started earlier in the fall and allowed to grow later in the spring. The greater the growth and the more nearly the crop can be allowed to approach maturity, the

Fig. 5.—An excellent covercrop of mustard in a Pajaro Valley orchard.

greater will be the amount of organic matter derived from it. Covercrops should produce from 10 to 30 tons of green material per acre. Legume crops may contain from 10 to 13 pounds of nitrogen per ton of material. Little if any beneficial effect is usually evident from the use of either manures or covercrops until the second season.

Animal Manures.—Since manures add nitrogen and at the same time improve the physical condition of the soil, they have long been recommended. At present, however, their scarcity limits their use. When the cost is not prohibitive, applications of ordinary barnyard manure may be made at the rate of 6 to 10 tons to the acre. Poultry manure, largely used by Sebastopol growers, is usually applied in quantities of 2 to 3 tons to the acre. Applications are generally made in the dormant season. In fertilizing mature trees, the manure should be scattered well between the rows rather than immediately adjacent to the tree trunk.

Commercial Fertilizers.—The application of commercial fertilizers to orchard soils has definitely improved the growth of the covercrop and, according to some, the growth of the trees and the fruit. Nitrogenous fertilizers such as ammonium sulfate, ammonium phosphate, and calcium nitrate have given best results. The usual rate of application recommended is 2 to 3 pounds per tree for young trees and from 4 to 6 pounds for those of bearing age. If only one application is made, it had best be scattered over the surface of soil under the branches just before the spring disking. In some instances dividing this application and applying half the amount the previous fall has given a greater covercrop yield.

Irrigation.—Where bearing trees will produce 8 to 10 inches of new wood each year and a satisfactory annual crop of good-sized fruit, irrigation would seem unnecessary. If, however, wood growth is scanty and the fruit, even when properly thinned, fails to size properly and is of poor quality, lacking in crispness and flavor, irrigation should be considered. The success of many orchards will largely depend upon whether the owner can supply water during the growing season. In other instances the water is probably being applied uselessly.

The essentials in connection with the irrigation of orchards have been fully covered in a previous publication.[9] A supply of available moisture throughout the growing season is the condition desired, and frequent examination with a soil auger is the most satisfactory method of determining the necessity for and the frequency of irrigation.

Sufficient water should be applied to secure thrifty but not excessive or rank wood growth. Light, sandy soils or soils underlain with a substratum of gravel may require frequent applications, while the heavier clay loams may need only one or two. The latter is the usual practice in the irrigated orchards of the more important districts. Type of soil, topography, the amount of water available, and the cost will determine the most satisfactory way of applying water. The chief essentials, however, are even distribution and good penetration. The most common methods are the contour-check system of flooding and the furrow system, in which six to eight large furrows 6 inches or more in depth are made between each two rows of trees. Contour furrows are best adapted to foothill and mountain sections.

Thinning.—The value of fruit thinning is now well recognized and in years of heavy crop yields is one of the most important orchard operations. Removing the surplus specimens aids in increasing the size, color, quality, and uniformity of the fruit, prevents breaking of limbs, assists

[9] Veihmeyer, F. J., and A. H. Hendrickson. Essentials of irrigation and cultivation of orchards. California Agr. Ext. Cir. 50:1–24. Rev. ed. 1936.

in maintaining the general vigor of the trees, makes spraying more effective, and decreases the labor of handling the crop at harvest time.

In general, thinning should be practiced sufficiently to produce at least moderate-sized fruit and relieve the overburdened trees. Since the food supply of the fruit is elaborated in the leaves, the size of the fruit is materially influenced by the ratio between the number of leaves (or total leaf surface) on the tree and the number of fruits. For certain important varieties, 40 to 50 leaves per fruit seems most desirable.[10] To determine the exact number of fruits and leaves on a full-bearing tree (60,000–100,000 leaves on a tree) is, however, obviously impracticable; hence actual thinning recommendations are still based on spacing the fruits at certain distances. A distance of 6–8 inches apart is generally satisfactory. Another method is to remove enough specimens so that when the fruits attain their full size they will be 4 to 6 inches apart on the branch. Unless the set of fruit is very uneven, clusters should be thinned to one apple each.

No definite dates can be given for thinning, because they vary with the variety, the season, and general climatic conditions. In most instances, however, a natural drop of young fruits occurs several weeks after the blossoming period. Immediately thereafter, while the apples are still small and before the seeds develop to any extent, the surplus fruits had best be removed.

Bracing and Propping.—Well-pruned and well-thinned trees should need relatively little bracing or propping. In many instances, however, because of weak crotches, extra long horizontal limbs, and light or no thinning, considerable damage may occur. For open-centered trees or others whose main branches are structurally weak, the central wire-bracing system, with wires running from screw eyes or staples in the branches to a ring in the center of the tree, may be used to good advantage. This type of bracing is permanent except for repairing broken or tightening loose wires.

In most apple orchards, however, where smaller outside limbs are most in need of support, wooden props are used. Naturally these must be placed each season and taken down again at harvest time.

Frost Protection.—Since the larger apple sections of the state are at low altitudes and relatively near the coast, frost danger to the blossoms or young fruit is infrequent, and few growers are prepared to heat their orchards. At altitudes of 4,000 feet or higher, spring frosts may do considerable damage or even destroy the crop one year out of four or five.

[10] Magness, J. R., F. L. Overley, and W. A. Luce. Relation of foliage to fruit size and quality in apples and pears. Washington Agr. Exp. Sta. Bul. 249:1–26. 1931.

Even under these conditions, however, the returns from the crop lost would probably not justify the necessary investment in fuel, storage tanks, wagons, heaters, thermometers, and other equipment that would be of little or no use in most years.

PRUNING

Young trees are usually trained to one of two systems: the open-center or vase-shaped tree; or the modified leader, sometimes called delayed open-center type. With the open-center system of training, three branches are preferably chosen to form the framework. These are all pruned to maintain an equal size as nearly as possible. Any tendency of a branch to outgrow the others and assume the lead is suppressed. The advantages attributed to this system of training are that it forms an open, spreading, low-headed tree, producing highly colored fruits. The principal objection or disadvantage is that the scaffold branches tend to issue from one point, and thus produce a tree structurally weak (fig. 6).

The modified leader or delayed open-center tree results, as the name would indicate, from a system of training intermediate between the open-center and the central-leader type of tree grown in the eastern states. It is started by letting the topmost branch assume the lead for two to five years. Thus one obtains greater spacing of the scaffolds on the trunk, secures strong crotches, and at the same time keeps the tree relatively close to the ground. Apparently this type has much in its favor and should be grown to a greater extent.

Starting the Main Branches.—The height of the trunk is determined when the tree is first headed. The main stem should be left high enough so that approximately 6 inches will intervene between the main scaffolds and yet the lowest branch will not be too near the ground. A height of 24 to 30 inches is recommended. As a rule, only three main branches well distributed around the trunk as well as up and down are desired. Observations show that at 5 feet from the ground five to seven secondary stems are usually all that the bearing tree can carry without crowding (fig. 7). If young trees are already branched when planted, the side branches suitably located may be only shortened, rather than cut off. All superfluous branches, however, should be removed.

First Summer's Pinching.—Where young trees grow vigorously the first season, summer pinching of the surplus shoots when 3 or 4 inches long is sometimes practiced. Such pinching, done at this time, results in more vigorous growth of the branches selected to form the main framework, in better-shaped trees, and in less cutting at the first winter pruning. Sometimes the trees should be gone over again in about six weeks to

suppress any new undesirable growth that may have started after the first pinching.

First Dormant Pruning.—At the first dormant pruning, which in California may be given any time after leaf fall and the beginning of

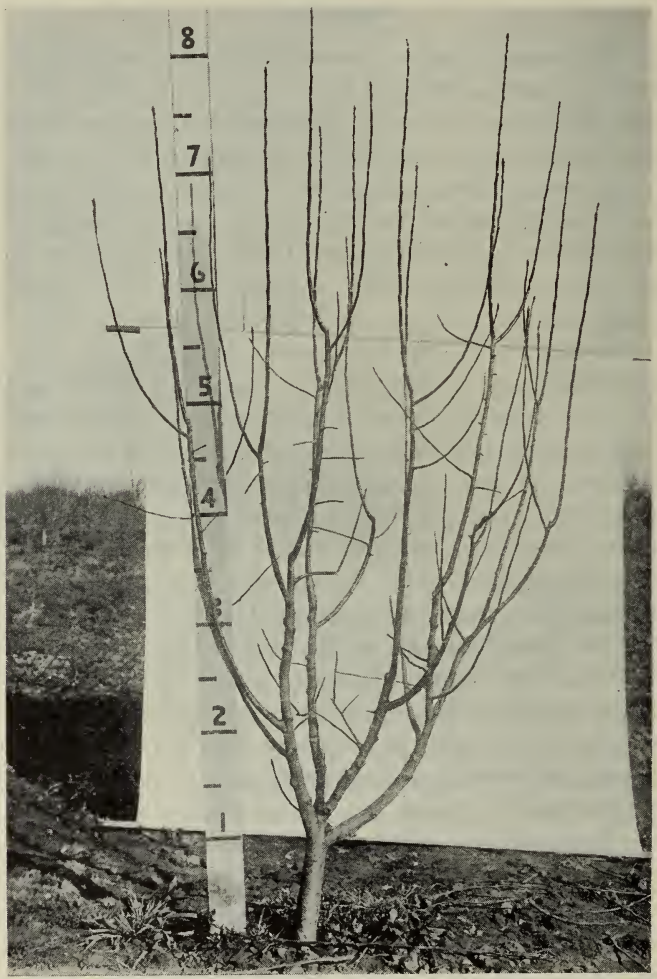


Fig. 6.—Four-year-old Red Astrachan tree after pruning. Branches thinned only. The two lowest branches make a poor crotch, due to low heading and poor training the first year.

activity in the spring, the scaffold branches should be headed back 15 to 30 inches or more from the juncture with the tree trunk. As the primary reason for this heading is to induce more branching, the limbs should be cut at the approximate height where the second branches are

desired. To secure the modified-leader type of tree, head back the uppermost branch very lightly. Where the variety naturally makes a spreading growth, head the branches somewhat severely, cutting to an inside bud. Where the growth is upright and a greater spread is desired, cut to an outside bud.

The first dormant pruning is of great importance because the tree is being shaped as it should grow. The severity of pruning will also have a marked effect upon the age at which the tree will come into bearing.

Fig. 7.—Close view of bearing tree showing crowding of main branches.

Second Summer's Pruning.—From the main scaffold branches chosen and headed back at the first dormant pruning, numerous shoots are apt to start. Some of these, if not suppressed, may outgrow those desired for secondary branches. The tree may also become so filled with new wood that severe thinning will be needed the following winter. It may be advantageous, therefore, to go over the trees early in the second summer when the new shoots have attained a length of 6 to 10 inches and pinch back all undesirable growth. If the desired number of well-spaced scaffold branches were secured at the last pruning, two shoots from each of these will be sufficient to leave. If even distribution was not obtained, one or more additional shoots well placed may fill a vacancy and produce a better-balanced tree.

Second Dormant Pruning.—Where the trees are summer-pruned as outlined above, the second dormant pruning should usually consist only of thinning out superfluous, interfering, and misplaced branches. Such a variety as Spitzenburg (fig. 8) may necessitate heading of the secondary branches to induce further branching at the desired height. With most varieties, however, this practice is not necessary and means additional pruning later on, with consequent delay in the time required for the tree to reach commercial production. Any extra-long or overvigorous

Fig. 8.—Five-year-old Spitzenburg tree showing long, rangy growth of branches. Note excellent set of fruit spurs.

branch growing at the expense of the others or destroying balance should be subdued by heading. Heavy or severe cutting will check the growth of any branch, whereas light pruning or none at all will encourage most rapid development.

Third and Fourth Dormant Pruning.—Pruning during the third and fourth years is largely a continuation of that given the second year. Continue to thin out unnecessary and interfering branches, water-sprout growth, and perhaps some small branches near the ground that hinder cultivation. Keep the center of the tree open to sunlight; yet avoid pruning the limbs up "clean" by removing all the short branches that should naturally develop into fruiting wood.

Pruning Bearing Trees.—Trees properly cared for during their formative period should be well shaped and mechanically able to support

heavy loads. Although some varieties, such as Rome Beauty, Jonathan, and Wagener, produce much of their fruit on the tips of last year's branches and although on the Pacific Coast a number of varieties may produce fruit laterally on one-year twigs, most of the crop is produced terminally on short branches or on spurs originating from wood two

Fig. 9.—Typical pruning of a full-bearing Gravenstein apple tree in a Sebastopol orchard.

years old or older. These spurs normally begin to form after three to five years, or when the young tree naturally tends to slacken its vegetative growth.

The primary consideration, therefore, in pruning bearing trees is to maintain a proper balance between vegetative growth and fruit production. Excessive growth by the young tree is usually produced at the expense of fruit production, while overbearing is accompanied by less growth and if continued may destroy vigor. The ideal condition during the years of maturity is for the trees to make 6 to 10 inches of new growth

Fig. 10.—Typical Yellow Newtown trees in a Pajaro Valley orchard, illustrating the general type of pruning used and something of the fruiting area of the tree. Note growth of the horse-bean covercrop.

Fig. 11.—Typical Yellow Bellflower orchard in the Pajaro Valley. The trees show the result of heavy crop production. Props from the previous year still remain in the orchard.

each year, and thus increase and maintain the fruiting area while producing large but not excessive annual crops.

With most varieties that previously have received regular pruning, there is little necessity for more than a light annual thinning. The center of the tree should be kept fairly open. Trees attaining too great a height may be lowered by cutting back some of the larger upright branches to strong laterals (fig. 9). Light crops and a large amount of vegetative growth would indicate that previous pruning practices had been too severe. Such trees should receive very little dormant pruning.

Pruning Old Trees.—Old bearing trees, producing heavy crops of small-sized fruit, or those not making 6 to 8 inches of new wood growth annually, require somewhat heavier pruning than younger trees in order to secure the desirable amount of new growth and to maintain the vigor of the fruiting spurs. Moderately heavy thinning of the smaller branches also reduces the amount of fruit thinning necessary in years of heavy production. Figures 10 and 11 illustrate the appearance of typical Yellow Newtown and Yellow Bellflower trees in the Pajaro Valley.

Treatment of Pruning Wounds.—Whenever one must remove limbs larger than an inch or so in diameter, he should protect the pruning wounds with some covering in order to exclude rot-causing fungi. For this purpose commercial preparations may be used. Bordeaux paste is also employed by some growers in the Pajaro Valley. In recent years a more nearly permanent covering, bordeaux powder combined with paint, has given good results. An excellent formula is:

1 gallon paint (formula similar to Fuller's "contour" paint)
1¾ gallons boiled linseed oil
7 pounds of bordeaux powder ("one-package" bordeaux)

APPLE DISEASES AND THEIR CONTROL[11]

The apple, like most other plants, is subject to infectious diseases caused by fungi, bacteria, and viruses; and to noninfectious disorders, usually due to unfavorable action of soil or weather. The fungus and noninfectious diseases discussed here include most of those known to be important with respect to apples, in this state.

Powdery Mildew.—The principal foliage disease of apples in California is powdery mildew, caused by the fungus *Podosphaera leucotricha,* and is particularly prevalent in the Pajaro Valley. A superficial white powdery fungus growth appears on leaves, shoots, and sometimes fruits, and dwarfs and distorts the leaves and shoots if they become affected early.

[11] This section and that part of table 2 which deals with diseases were contributed by H. Earl Thomas, Associate Plant Pathologist in the Experiment Station.

Since the fungus hibernates in buds, especially terminal buds, mildewed shoots should be removed at pruning time. The principal control measure consists in spraying at the cluster-bud stage with 2 gallons of liquid lime-sulfur or 5 to 10 pounds of wettable sulfur to 100 gallons of water and again with the wettable sulfur at the calyx period. If mildew has been permitted to accumulate in the orchard, two or three years may be required to bring the disease under control.

Scab.—Scab, caused by *Venturia inaequalis,* is occasionally important where rainy weather continues after growth of the tree is under way. Superficial velvety dark-olive to black spots are formed on fruits and leaves. The tissues beneath the scab spots are often dwarfed, resulting in misshapen fruits. Older scab spots from which the fungus has weathered away have a russeted appearance.

In most cases two spray applications at the cluster-bud and calyx stages should control the disease. Orchards heavily infested may need an early application when the leaves of the flower buds are about ½ inch long. Either lime-sulfur (1–50) or bordeaux mixture 3–3–50 is effective if fortunately timed. The latter material is more apt to russet the fruit.

Root Rot.—In the root rot, caused by *Armillaria mellea,* trees are killed slowly and usually from the center outward in a rather definite area in the orchard. This fungus (often also called oak root fungus) spreads through the roots and crowns, producing characteristic whitish, fan-shaped mycelial mats within and just beneath the bark. Since the apple is less susceptible than certain other of the fruit trees, the progress of the disease may be considerably delayed (though not stopped) by removing the soil from the crowns and larger roots of slightly affected trees and leaving these exposed during the dry season. Some benefit may also result from cutting off affected roots and bark of trees in the initial stages of the disease. Wounds made in this operation should be covered with a fungicide such as mercuric bichloride (1 part in 1,000 parts of 25 per cent denatured ethyl alcohol in water).

A root rot similar in appearance but caused by a different fungus, *Rosellinia necatrix,* has been found in a number of orchards. This may sometimes be distinguished from *Armillaria* root rot by the absence of well-defined fan-shaped mats in the bark and by the presence of loose cottony wefts of fungus mycelium in the moist soil around infected roots. A laboratory test is often necessary, however, to separate these diseases with certainty. No satisfactory control is known.

Crown Gall, Hairy Root, or Woolly Knot.—In this disease, irregular, rather spongy tumors occur on the crowns and roots, with or without an excessive development of fine fibrous roots. The causal organism is *Bac-*

terium (*Phytomonas*) *tumefaciens*. The most destructive form originates in the nursery, often at the graft union. The apple is less affected than certain other fruit trees, notably the peach, and is usually not severely injured in the orchard.

One should, however, plant only trees with vigorous roots and smooth graft unions free from visible tumors. Galls that appear on the crowns in the orchard may be cut off with a chisel, and the wounds covered with bordeaux paste. This treatment aids in preventing the entrance of other disease organisms into the tree through the old galls.

Fire Blight.[12]—Blight, caused by *Bacillus* (*Erwinia*) *amylovorus*, affects all parts of the apple as is the case with the pear, cotoneaster, loquat, pyracantha, quince, and toyon. The bacteria overwinter in diseased bark and usually invade the tree through the blossoms. Less frequently they enter through the young shoots and cause these to wither and turn brown. The bacteria form cankers (dead areas in the bark) on larger branches, trunks, and roots around the bases of blighted fruit spurs and shoots. A milky or brownish sticky fluid often oozes from diseased parts.

The disease is favored by warm, humid weather, especially at blossoming time, and by vigorous growth.

The blossoms, shoots, and many of the roots of commercial varieties are highly susceptible; but varieties differ widely in the susceptibility of the trunks and larger branches. In this regard Alexander, Spitzenburg, and Tompkins King are highly susceptible; Jonathan and Wagener moderately so; Delicious, Gravenstein, Rome Beauty, Stayman Winesap, Winter Banana, Yellow Bellflower, and Yellow Newtown comparatively resistant.

Control in apple trees resembles that in pear, the main feature consisting in removing all infections as far as possible, during the dormant season. The smaller affected branches are cut off. Cankers on larger branches are cut out down to the wood, including a zone of live bark on all sides 2 to 3 inches wide. With more susceptible varieties, the new infections should be removed in the spring soon after blossoming time. A close watch should always be kept for the blight that may develop in roots and crowns through infection of root suckers. Wounds from blight-eradication work should be treated with a good germicide such as is made by dissolving 1 part of mercuric chloride and 1 part mercuric cyanide in 500 parts of a solvent consisting of 10 per cent glycerine in water. *This solution is a deadly poison.*

[12] For more complete information see: Thomas, H. Earl, and P. A. Ark. Fire blight of pears and related plants. California Agr. Exp. Sta. Bul. 586:1–44. 1934.

Dieback.—Several types of injury to the root system or other parts of the tree may be followed by dying-back of terminal shoots and branches. A seemingly small part of the dieback in the state is associated with little-leaf or rosette (which see), and another part is directly related to poor drainage. Some dieback, however, not clearly related to these conditions, is sometimes found in the Sebastopol area. The buds fail to start or die soon after growth has begun, and the shoots die from the tips downward. In severe cases the bark of larger branches and trunks breaks down, sometimes with a sour odor. Although the trunks and larger roots are usually sound in appearance, many of the fine feeding roots are dwarfed or killed outright. This type of injury is almost never found in areas amply supplied with the clay subsoil characteristic of the district. Rather it seems related to the types of subsoils containing little clay but sometimes containing cemented layers (more or less impervious to water) or sandstone bedrock near the surface.

Careful selection of orchard sites and drainage of obviously wet areas are suggested. In the Sebastopol area, repeated covercropping is apparently of value in this connection.

Sappy Bark.—In the condition known as sappy bark, caused by the fungus *Polystictus versicolor,* the bark is soft and spongy during wet weather, loose and papery in dry weather; and the wood beneath breaks down with a punky rot. In vigorous trees the heartwood may rot extensively, with little or no evidence in the bark until later stages. Usually the leathery, bracket-type fruiting bodies of the fungus appear eventually on dead bark or wood.

The prevention of this disease requires the continuous protection of unhealed wounds. Bordeaux paste is a good fungicide in this connection, though it involves more frequent renewal than certain other materials. Careful pruning early in the life of the trees will later obviate the necessity for large pruning wounds.

Little-Leaf or Rosette.—Although apples are highly susceptible to little-leaf, most of them in the state are grown in districts where the disease is not prevalent. In mild cases the shoot toward the tip produces leaves progressively smaller, paler, and closer together, giving in the end the appearance of a tuft or rosette. The tip of the shoot is often distinctly thickened. In severe cases the shoots and branches may die back or may survive with little or no terminal growth, the buds developing slowly and the leaves remaining small and narrow.

Affected trees may be cured by zinc applied in any of several different ways. The most satisfactory method has proved to be spraying during the dormant season with 25 pounds of zinc sulfate in 100 gallons of water.

Other Noninfectious Diseases.—For other noninfectious diseases, including bitter pit, internal browning, scald, and other similar troubles affecting the fruit, see the section on storage troubles.

INSECT PESTS AND THEIR CONTROL[13, 14]

The most important insect pests of the apple in California are the codling moth, scale insects, and aphids. Other insect pests occur only in certain localities or at certain seasons.

Codling Moth.—The codling moth (*Carpocapsa pomonella*) undoubtedly causes the greatest loss of all insect pests to apple growers throughout the state and demands a complete spray program properly timed. The attendant problem of spray residue necessitates careful planning of spray applications. Practically all programs require some efficient means of removing the spray residue to meet the tolerance requirements (p. 56).

There are two definite broods of this moth each season: the first, from March to June; the second, from July to October. Effective control of the first brood is most important; it eliminates not only the so-called "calyx-worms" at harvest but also the possibility of small "side" worms of the second brood. This is best accomplished by using the proper dosage and timing in the calyx spray and in the first two cover sprays. The calyx spray should be applied when approximately two-thirds of the petals have fallen; the first cover spray 10 to 14 days later. The dosage for these first two sprays is as follows:

Powdered standard lead arsenate	4 pounds
Fluxit-type spreader	½ pound
Water	100 gallons

Subsequent cover sprays are best timed with the codling-moth bait-trap emergence records;[15] but in the absence of such records applications at three-week intervals, repeated as often as necessary, have proved satisfactory. The dosage for these cover sprays should be as follows:

Powdered standard lead arsenate	3 pounds
Fluxit-type spreader	½ pound
Water	100 gallons

No substitute for standard lead arsenate thus far tried has proved satisfactory.

Besides spray control one should give special attention to orchard

[13] This section and that part of table 2 which deals with insect pests were contributed by A. D. Borden, Assistant Entomologist in the Experiment Station.

[14] For additional information on insect pests and their control see: Essig, E. O., and W. M. Hoskins. Insects and other pests attacking agricultural crops. California Agr. Ext. Cir. 87:1–155. 1934.

[15] Borden, Arthur D. Codling-moth bait traps. California Agr. Ext. Cir. 63:1–13. 1932.

sanitation, which includes thinning out infested fruit, destroying windfalls and culls, banding to kill overwintering larvae, and general orchard and packing-house sanitation.

Scale Insects.—The well-known San Jose scale (*Aspidiotus perniciosus*) is a small, circular, cone-shaped gray scale and causes a characteristic red or purplish stain on the bark and fruit. For control, spray in full dormant period with lime-sulfur solution (1–10); or with tank-mix[16] oil of winter grade (3–100); or with commercial winter oil emulsion (5–100).

The oyster-shell scale (*Lepidosaphes ulmi*) resembles a miniature oyster encrusted on the trunk or small limb, is light to very dark brown in color, and overwinters largely in the egg stage. For control, spray in full dormant period with lime-sulfur solution (1–8); or with tank-mix oil of winter grade (4–100); or with commercial oil emulsion (6–100), plus 3 gallons lime-sulfur solution to each 100 gallons of spray.

The soft-scale insects known as mealybugs (*Pseudococcus maritimus*) may infest all parts of the tree and excrete quantities of honeydew, causing a smutty appearance of fruit and foliage. The mature insects are flattened, oval, soft-bodied, and covered with a powdery wax that extends from the sides in a series of short filaments. The oval, pale-yellow eggs are deposited in a cottony mass. For control, spray in full dormant period with a combination spray made according to the following formula:

Dormant commercial oil emulsion or tank-mix dormant oil emulsion 4–100	5 gallons
Commercial lime-sulfur solution	3 gallons
Water to make	100 gallons

For control in spring and summer, spray every few weeks with commercial summer oil emulsion (2 to 3 per cent) or with tank-mix foliage oil spray (1½ to 2 per cent).

For control of the greedy scale and the brown apricot scale, spray in full dormant period with dormant tank-mix oil (3–100) or with dormant commercial oil emulsion (4–100).

Aphids.—The rosy apple aphid (*Anuraphis roseus*) and the green apple aphid (*Aphis pomi*) are distinguished by their color, the characteristic curling of the leaves, and the stunting of the young fruits. They overwinter in the egg stage, the eggs having been deposited in the late fall on the fruit spurs and buds. For controlling the egg a new spray material known as coal-tar distillate emulsion has proved very effective. It should be applied in the full dormant period at a concentration of 2½

[16] Borden, Arthur D. The tank-mixture for dormant oil spraying of deciduous fruit trees in California. California Agr. Exp. Sta. Bul. 579:1–20. 1934.

per cent actual creosote oil per 100 gallons of water. This material, being very caustic, must be handled with care.

For controlling hatched insects the addition of nicotine sulfate (Black Leaf 40, ¾ pint to 100 gallons of spray) to the cluster-bud and calyx sprays is often advisable if temperature conditions are favorable. Hand-picking of infested fruit and leaf spurs is often practiced.

The woolly apple aphid (*Eriosoma lanigera*) has a reddish body, completely covered with white woolly wax. It infests both root system and aerial parts of the tree, causing characteristic nodule swellings of the roots and twigs and smutting of fruit and foliage.

To control the root infestations use paradichlorobenzene during the fall. For overwintering aphids on the tree, spray in full-dormant period with 3 per cent dormant oil emulsions under high pressure. For summer infestations of fruit and foliage, spray with the following solution:

Liquid whale-oil soap	1½ gallons
Nicotine sulfate	¾ pint
Water to make	100 gallons

Fruit Tree Leaf Roller.—The pest known as the fruit tree leaf roller (*Archips argyrospila*) attacks foliage and young fruit soon after the buds open in the spring, tying leaf clusters together and feeding on immature fruit and foliage. The caterpillars are difficult to control after they have rolled the leaves together. Oil emulsions applied in the full dormant period will destroy the egg masses usually found on the higher branches of the tree. Use tank-mix dormant oil (4–100) or commercial dormant oil emulsion (7 or 8 gallons to 100).

Tussock Moth.—The brilliantly colored caterpillars of the tussock moth (*Hemerocampa vetusta*), clothed with tufts of black and white hair, are more commonly known as horned caterpillars. The grayish-white, felty egg masses are found, during the winter, on the trunk and limbs where wingless female moths deposited them in late summer and fall.

Hand-picking and destruction of the egg masses in winter and tanglefoot banding of the tree trunks in the spring give the most efficient control. Poisonous sprays are of little value except in the very early spring.

Skin Worm.—The skin worm (*Cacaecia franciscana*), often a serious pest on apples in the coastal areas, feeds on the skin of the fruit at points of contact, and at the stem and blossom ends. It overwinters as larvae and pupae, the adult emerging and depositing egg masses on trunks, main limbs, and foliage from before the time of bloom until late summer. Best control is obtained by destroying the egg masses. An early application of 2½ per cent lime-sulfur solution or 2 per cent winter oil emulsion

on the trunk and main limbs will destroy the egg masses before blossoming time. Two or three applications of summer-type oil emulsion (2 gallons to 100) on foliage and fruit at intervals of three weeks after blossoming will destroy later broods. Usually about three applications are sufficient.

Pandemis.—The pandemis insect (*Pandemis pyrusana*), often confused with the fruit tree leaf roller, feeds on the leaves and fruit. It overwinters as an immature larva and is controlled by spraying with dormant oil emulsions (3 per cent) and nicotine sulfate (¾ pint to 100 gallons spray).

Tent Caterpillars.—Occasionally the coast tent caterpillar (*Malacosoma pluvialis*) and other species attack fruit trees. The compact nests may be pruned out or torched. Spraying with arsenate of lead gives effective control.

Western Flat-headed Borer.—The beetle known as the western flat-headed borer (*Chrysobothris mali*) deposits eggs in sunburned or other dead areas of the trunk, and the larvae later burrow into the wood. Their damage to two and three-year-old plantings is often serious. For control, prevent sunburn by using tree protectors or whitewash the trunks and dig out the borers.

Leafhopper.—Occasionally in the coastal areas the apple leafhopper (*Empoasca mali*) not only damages the foliage, but also spots the fruit with its excrement. Control measures should be directed against the nymphs by spraying with nicotine-soap sprays or dusting with 5 per cent dust.

Mites or Red Spiders.—The brown mite (*Bryobia praetiosa*), the European red mite (*Paratetranychus pilosus*), and the common red spider (*Tetranychus telarius*) often build up populations sufficient to cause injury. The first and second species overwinter in the egg stage and may be controlled with the usual dormant oil emulsion sprays. Summer infestations of any species may readily be controlled with the following spray:

Liquid lime-sulfur solution	1 gallon
Wettable sulfur	5 pounds
Water to make	100 gallons

Summer-type oil emulsions (1½ gallons to 100) added to lead sprays may be substituted when a combination spray is indicated.

SPRAY PROGRAM

Fortunately apple growers in any one section do not usually have to combat all the diseases and insect pests previously mentioned. In some sections certain of these may be almost unknown. On the other hand, one

TABLE 2

Spraying Schedule for Control of the Most Common Insects and Diseases of the Apple

Time of application	Pest or disease	Spray materials and strength
Dormant period (January and February), before buds open	San Jose scale and mite eggs*	3–4 gallons dormant spray oil to make 100 gallons dilute spray, by tank-mix method; or 5–6 gallons dormant oil emulsion to make 100 gallons; or 10–12 gallons lime-sulfur solution to make 100 gallons.
	Oyster-shell scale and mealybug	4 gallons dormant spray oil to make 100 gallons dilute spray, by tank-mix method; or 5 gallons dormant oil emulsion to make 100 gallons, plus 3 gallons lime-sulfur solution for each 100 gallons of spray.†
	Fruit tree leaf roller eggs	4 gallons dormant spray oil to make 100 gallons dilute spray, by tank-mix method; or 7–8 gallons dormant oil emulsion to make 100 gallons.
	Green and rosy apple-aphid eggs	Coal-tar distillate emulsion (2½ per cent actual creosote oil to each 100 gallons of dilute spray).
Delayed dormant buds in green-tip stage	Skin-worm eggs	2½ gallons lime-sulfur solution to each 100 gallons of spray solution; or 2 gallons dormant oil emulsion to each 100 gallons of spray applied to trunk and main limbs.
	Scab	2½ gallons lime-sulfur solution to each 100 gallons of spray solution.‡
Cluster-bud stage (before petals open)	Scab and powdery mildew	2 gallons lime-sulfur solution to each 100 gallons of spray solution or 5 to 10 pounds of wettable sulfur to each 100 gallons of solution.
	Aphids (newly hatched)	Add ¾ pint nicotine sulfate to each 100 gallons of dilute spray in the above dosage.
	Skin-worm eggs (second spray)	2½ gallons of lime-sulfur solution to each 100 gallons of spray solution—covering trunk and main limbs.
Calyx period when two-thirds of petals are off	Codling moth (calyx spray), scab, and mildew	4 pounds standard lead arsenate per 100 gallons of spray and 5 to 10 pounds wettable sulfur to each 100 gallons.
	Aphids	Add ¾ pint nicotine sulfate to each 100 gallons of spray in the above formula.
First cover (10-14 days later)	Codling moth	4 pounds standard lead arsenate per 100 gallons of spray.
	Mildew (Sonoma Co.)	3 to 5 pounds wettable sulfur per 100 gallons of spray.
	Skin-worm eggs (third spray)	See table footnote ¶.

For footnotes, see end of table, next page.

TABLE 2—(*Concluded*)

SPRAYING SCHEDULE FOR CONTROL OF THE MOST COMMON INSECTS AND DISEASES OF THE APPLE

Time of application	Pest or disease	Spray materials and strength
Second cover, timed by bait-trap catch, or within 3 weeks...	Codling moth.....	3 pounds of standard lead arsenate to each 100 gallons of spray, with addition of a suitable spreader.
	Leafhopper nymphs....	Add ¾ pint of nicotine sulfate to the above lead spray; or dust with 5 per cent nicotine dust.
Third cover, when necessary, timed by bait-trap catch	Codling moth.....	3 pounds of standard lead arsenate to each 100 gallons of spray, with addition of a suitable spreader.
Fourth and fifth cover, when necessary, timed by bait-trap catch	Codling moth.....	Same as dosage above.

* Mite eggs are more effectively controlled by use of oil emulsions.

† Lime-sulfur solution is not compatible with all oil emulsions; it is compatible with tank-mix and most paste-type emulsions.

‡ This application will be necessary only under severe scab conditions.

¶ Applications of oil emulsions on foliage with sulfur present may cause defoliation. If skin-worm eggs are still present, consult your county agent.

or two may be of the greatest importance and may require special control measures. Differences in climatic conditions and in the relative importance of certain diseases and insect pests will therefore cause some variation in spray practices. The relative time of applying the spray, however, and the materials used are rather uniform; hence, apple growers generally will follow, in part at least, the program given in table 2. When in doubt as to the proper material or dosage or the possible injury, consult your County Farm Advisor or County Agricultural Commissioner.

HARVESTING

Time of Harvesting.—Harvesting dates are determined by (1) the variety, (2) the season, (3) the location, and (4) the purpose for which the fruit is intended.

Early apples to be marketed locally in limited quantities and solely for cooking may logically be harvested considerably in advance of their full size and color or the development of their characteristic flavor. There is a definite demand for a limited quantity of such fruit when all else is sacrificed for earliness. This demand for an inferior product is, however, soon filled; and to harvest the more important summer and fall varieties so as to fill an order by a certain date, with no regard for maturity, cannot be recommended. Premature harvesting, though undoubtedly advantageous to certain individuals, can only result in fruit of poor color

and low quality. A few such shipments soon have a depressing effect upon the subsequent returns that the majority of growers are able to realize for the larger part of their crop. First shipments of California Gravensteins, the first boxed apple to arrive on the eastern markets and offered as a dessert apple, have frequently lacked their characteristic flavor and color. Bitterpit, a physiological trouble that develops much less on well-matured fruit, is also frequently so serious as to discount any advantages of extreme earliness.

Although premature harvesting sacrifices size, color, and quality, too late harvesting may mean excessive dropping and poorer keeping quality. The importance of these factors largely depends upon whether the apples are to be stored and sold as fresh fruit, or dried. Fruit for drying may be somewhat more mature than fruit for long keeping in storage.

Considering the variety, the relative earliness or lateness of the season, and the purpose of the fruit, most commercial growers know from experience when their crop is ready. Their judgment is usually based upon several considerations, among which the following are the most important:

1. The ease with which the apple can be removed from the fruit spur. Dropping of sound apples is a natural sign of maturity, and most varieties when ready for picking can be broken from the spur rather easily.

2. The taste of the fruit. Specimens should be cut and tasted. If hard and starchy the fruit should, in all probability, be left on the tree for several days at least. No variety, of course, will possess at this time its characteristic aromatic flavor. The flesh should be decidedly firm and sharply acid, but with practically no starchy taste.

3. Changes in color. With red apples, full color development is desirable. Color, however, may vary rather widely in different districts and in different seasons. If the weather be cloudy or foggy, the fruit may be well developed and yet show little color when ready to pick. Where weather conditions just before harvest time are ideal for coloring, the fruit will assume its natural color often considerably in advance of the proper time for picking. Particularly may this be true of the red bud sports. The red or overcolor is therefore not an accurate indication of ripeness. In varieties that are only partially colored a much more accurate index is the green or yellow undercolor of the skin. Whenever this color begins to change from a decided green to a slight yellowish green, the fruit may generally be considered in the proper condition.

This initial change from the original dark green to a lighter shade is also applicable to green varieties. With the Yellow Bellflower, color differences may readily be observed; but with the Yellow Newtown they

can best be ascertained by comparison with the standard color chart used by the State Department of Agriculture.

4. Firmness of the flesh. Softening is an unmistakable sign of ripening. As the fruit pressure tester has shown, this softening starts before the normal time of harvest. Thus, accompanying increases in color of the fruit, there is normally a decrease in firmness. Both color and firmness can be measured rather definitely, and considered together they furnish a very good guide. Different varieties, however, vary in firmness just as in color; and firmness standards have been determined for only the more important varieties.

In addition to these picking indexes some growers believe that apples are ready for harvesting as soon as they attain a given size. Unless, however, size is considered with reference to other changes mentioned above, its value as a picking index is questionable.

The darkening of the seed in apples is another rather unreliable criterion sometimes followed to determine proper maturity for harvesting. Although some varieties do have dark seed when ready to eat out of hand, others are sufficiently mature to harvest for shipment before the change occurs. In other instances, notably in Yellow Newtown, the seed may be dark considerably in advance of the proper time for harvest.

Maturity Standards.—With the exception of a few varieties, the California Standard Apple Act,[17] which governs the grading, packing, and sale of all California apples, specifies that all apples offered for sale shall be properly matured, that is, "The apples in question at the time they were taken or fell from the tree, had reached the stage of development necessary to insure the proper completion of the ripening process."

As previously mentioned, most growers and the enforcers of this law know fairly well from experience when fruit is sufficiently matured. Early orders, however, frequently prompt growers to start harvesting too soon, so that some of the specimens at least may be so immature as to have the entire lot rejected by the local inspector, or to have its maturity debated upon arrival at destination.

To avoid possible differences of opinion between grower or shipper and the enforcers of the apple act, proper maturity of Gravenstein, Yellow Bellflower, and Yellow Newtown apples is now judged by certain color and pressure requirements. These standards have been formulated after several years of experimental work conducted jointly by the Division of Pomology of the Agricultural Experiment Station and the Division of Fruit and Vegetable Standardization of the State Department of

[17] A copy may be secured from the Division of Fruit and Vegetable Standardization, State Department of Agriculture, Sacramento, California.

Agriculture, who studied many samples harvested at different degrees of firmness and color development.

To be considered mature, Gravenstein, Yellow Bellflower, and Yellow Newtown apples must meet one of the following minimum standards:

TABLE 3

Minimum Maturity Standards of Color and Firmness for Harvesting California Gravenstein, Yellow Bellflower, and Yellow Newtown Apples

Variety	Color development*	Maximum pressure test in pounds†
Gravenstein	1½–2	17.5
	2	18.5
	3	No restriction
Yellow Bellflower	1½–2	17.0–18.0
	3	No restriction
Yellow Newtown	1½–2	22.0–23.0
	2½	No restriction

* Figures refer to those used on the State Department of Agriculture color chart: 1, original dark green; 2, light green; 3, yellowish green.

† Figures refer to the pressure in pounds necessary to force a $\frac{7}{16}$-inch plunger point into the flesh of the peeled fruit to a like depth.

In connection with this table it should be emphasized that all apples should show some slight lightening of the original green ground color before harvesting and that the fruit which meets only the minimum color requirements of 1½–2 will rarely, if ever, ripen with more than fair quality. Better size, greater yields, more red color and less bitter pit on Gravensteins, higher sugar content, and better storage and dessert quality will all be secured by allowing the fruit to attain greater maturity. Gravensteins and Yellow Bellflowers are more attractive and of much better quality where not harvested until light yellow. Yellow Newtowns are best when not picked until of a No. 2, or light green, to a No. 3 or yellowish-green color, according to the locality in which the fruit is grown or whether the strain is green or yellow.

Fruit harvested for drying should be fully matured but not soft.

Methods of Picking and Handling.—In harvesting, each specimen should be grasped in the palm and removed from the fruit spur by a quick upward turn of the wrist. A straight pull will result almost invariably in pulling the stem from the specimen and in tearing the skin in the cavity. Any such break affords a source of infection for various molds and rots. Tender varieties such as the Winter Banana and the Stayman Winesap must be picked with special care; otherwise they will show the finger marks of the picker, often within a few hours after

removal from the tree. To remove varieties that naturally grow in clusters, such as the Gravenstein, both hands must be used. When only one or two apples are picked from the cluster, those remaining are apt to drop.

Lug boxes are usually distributed ahead of the pickers and stacked between alternate trees in the row. As fast as the boxes are filled they are stacked, usually on the side of the tree protected from the afternoon sun. If the weather is warm, fruit picked in the forenoon should, if possible, be hauled to the packing-house before the heat of the day. Fruit picked in the afternoon is often left stacked in the orchard overnight and hauled in the following morning so that it reaches the packing-house comparatively cool. Any unnecessary delay between harvesting and placing the fruit under low temperatures will result in poorer keeping quality.

Pickers should always be warned against filling the boxes so full that when they are stacked upon one another the fruit will be bruised. Unless time is of utmost importance, pickers should be paid by the day rather than by the box. Although fewer boxes will be harvested, the fruit will show much less bruising, and the tree will be left in much better condition for next year's crop. In anticipating the actual quantity of fruit that any picker can harvest in a day, one must consider the size and distribution of the crop on the tree, the size of the tree itself, and the ease with which the fruit can be reached.

Considerable care should be used in loading and unloading from the wagon and in stacking boxes in the packing house. Pitching the boxes or allowing them to drop for even a few inches always bruises some fruit.

REMOVAL OF SPRAY RESIDUE[18]

Control of the codling moth, necessary for the production of marketable apples, demands the repeated use of lead arsenate spray. Even though not always apparent, some of this spray material usually remains on the fruit at the time of harvest. Since these residues may be deleterious to health, the federal and state laws require that all apples offered for sale, whether fresh or for drying, shall not show a residue in excess of 0.01

[18] For more complete information on spray residue removal than is given here see: Haller, M. H., Edwin Smith, and A. L. Ryall. Spray-residue removal from apples and other fruits. U. S. Dept. Agr. Farmers' Bul. 1752:1–25. 1935.

Cox, Alvin J. The California fruit and vegetable 1933 spray residue problem. Blue Anchor 10(12):8–11. 1933.

Anonymous. Washing apples and pears. Blue Anchor 11(3):7. 1934.

Cox, Alvin J. Warning to driers of pears, apples, or apple pomace with regard to spray residue. Blue Anchor 11(7):14–15. 1934.

Anonymous. Spray residue tolerance tightened. Blue Anchor 12(3):12–13. 1935.

Anonymous. Details of construction of home built type fruit washer. Blue Anchor 12(4):9. 1935.

Cox, Alvin J. Acid washing of fruit with the aid of heat. Blue Anchor 13(3):7. 1936.

grain of arsenic trioxide, 0.01 grain of fluorine, or 0.018 grain of lead per pound of fruit.[19] To meet this tolerance most apples must be cleaned.

Wiping.—In some instances the residue on early apples, including Gravensteins, may be so slight that wiping will be sufficient. Authorities on spray-residue removal state, however, that wiping removes not more than 25 per cent of the total residue present and that fruit may actually accumulate residue from the cloths or brushes and thus test even higher after wiping than before. Wiping can therefore be satisfactory only with fruit having very little excess residue and only with frequent changing of the cloths or brushes. As wiping has not been entirely satisfactory, it will doubtless gradually give way to washing.

Washing with Acid.—For washing California apples a weak hydrochloric acid solution (1 to 1½ per cent) has proved satisfactory. Commercial hydrochloric acid is approximately ⅓ acid, so that 3 gallons in a hundred are required to yield a 1 per cent solution. The common California spray practice makes unnecessary an alkaline wash such as sodium silicate, or the use of both alkali and acid as found necessary in removing the heavy oily residues in the Northwest.

Spray residue is most easily removed immediately after harvesting, especially with varieties that develop a large amount of wax on the skin. It is also more easily removed with a warm acid solution than with a cold one. Since many California apples are harvested in warm weather when water temperatures are relatively high, little attention has been given to heating the acid solution. The necessity for heating will be determined by the temperature of the water available, the strength of acid used, and the amount and nature of the residue to be removed. In districts where water temperatures at the time of harvesting may be only from 40° to 60° Fahrenheit, heating may be necessary. According to tests by the Division of Chemistry of the State Department of Agriculture,[20] apples successfully cleaned by a 1 per cent acid at 80° still carried an excess of residue when put through a 1½ per cent acid solution at 40° to 60°. In other instances even a 2½ per cent cold acid solution has failed to be effective unless the fruit was washed several times. Little additional cleaning is obtained by the stronger concentration of acid, more rinsing is necessary, and the solution is more corrosive to the metal parts of the washing equipment. A weaker solution at a higher temperature is therefore preferable.

[19] These tolerances are established for 1936. As improvements are made in cleaning it is expected that the tolerance for lead will be reduced to 0.014 grain per pound.

[20] Cox, Alvin J. Warning to driers of pears, apples, or apple pomace with regard to spray residue. Blue Anchor 11(7):14–15. 1934.

Cox, Alvin J. Acid washing of fruit with aid of heat. Blue Anchor 13(3):7. 1936.

Heating may be accomplished by electric immersion heaters, hot water or steam coils, or live steam released in the solution. Another very simple aid, tested by the Division of Chemistry, is a U-shaped piece of 4-inch iron pipe laid flat in the bottom of the acid tank and cut long enough so that both ends of the pipe extend several inches beyond the end of the tank. An upright vent is screwed on one end while a gas burner is attached to the other. Compressed industrial gas is used for fuel, the heat passing through the pipe serving to heat the solution.

It is difficult to make rules or general recommendations for all apple-growing districts and conditions; washing practices may be expected to vary in different sections. A 1 per cent acid solution is, however, the strength generally used. Salt may be added as an aid in removing arsenical residues. Soil particles and other materials on the fruit constantly weaken the acid and this loss must be periodically replaced. With agitation of the fruit or of the solution during washing, Cox states:[21] In general a consistantly maintained 1 per cent solution[22] of hydrochloric acid at 100° Fahrenheit with 10 to 15 pounds of ordinary salt added to each 100 gallons, is recommended as usually adequate for spray-residue removal in 40 seconds. The acid solution should be titrated every two hours and kept to full strength."

The operation of testing the strength of the acid is a simple one. The equipment needed is two 10-cc measuring pipettes graduated to 0.1 cc; a standard solution of sodium bicarbonate (23.0 grams to 1,000 cc of water containing 25 milligrams of methyl orange indicator); and a small bottle or cup. To make the test, fill one pipette from the acid tank, and allow the excess to flow out until even with the mark on the upper part of the stem. Then place the measured amount (exactly 10 cc) in the bottle or cup. Fill the second pipette with the sodium bicarbonate solution; and after allowing any excess above the mark to flow out, allow the solution to flow slowly into the container holding the acid, shaking it meanwhile. At the point where the color of the acid changes from red to yellow, note the number of cubic centimeters (cc) of sodium bicarbonate used. Divide this number by 10 to obtain the per cent strength of the acid. Thus if 7.5 cc of the sodium bicarbonate was required, the strength of the acid is 0.75 per cent. Always use the same pipette each time for the acid and for the sodium bicarbonate solutions, and rinse out the former with some of the acid solution to be tested before taking sample.

[21] Cox, Alvin J. [Mimeographed announcement; no title given.] California State Dept. Agr. April, 1936.

[22] Commercial hydrochloric acid tests 20° Baumé, which indicates a concentration of only approximately 32 per cent total acid. Three gallons of the concentrated acid are therefore added to each 100 gallons of water to secure a 1 per cent solution.

To increase the concentration to any desired point, add one quart of acid per 100 gallons for each 0.09 per cent of acid desired. To increase a 0.75 per cent solution to a 1.00 per cent solution would require a 0.25 per cent increase or approximately 3 quarts of acid.

During the washing process, dirt, decay spores, and residue are removed from the fruit; this necessitates renewing the acid daily or after 1,000 to 1,200 boxes have been put through 100 gallons of solution. In commercial washers the acid is usually drained off after each day's run, and the tank rinsed out.

After the acid wash, the fruit should be rinsed thoroughly to prevent damage from the acid solution or soluble residues. A simple test to determine whether or not all the acid has been removed is to taste the water in the calyx basin of the apples; if sour or tart rinsing is incomplete. For most efficient rinsing a continuous supply of fresh water should be added to the rinse tank as a spray on the fruit as it leaves the tank. Where only a limited supply of water is available, so that rinse water must be used continuously, it may be kept neutral by frequently adding small quantities of lime (approximately 2 pounds to each 50 gallons of water[23]). In that case, however, the rinse water should be renewed as often as possible.

Drying of washed fruit is not considered essential, although, to facilitate packing, most commercial washers are provided with some means of removing the excess moisture.

There should be no damage to or shortening of the storage life of sound apples that are properly washed and rinsed. Improper handling or lack of attention to the washing process may, however, result in such injuries as (1) acid burning, caused by leaving the fruit in the acid for an excessive period; (2) arsenical injury, caused by soluble forms of arsenic building up in the washing vat or remaining on the fruit after washing; and (3) heat injury, caused by permitting the temperature of the washing solution to get too high.[24] Obviously the remedy is to remove the cause.

Washing Equipment.—The type of washing equipment used will be determined largely by the quantity of fruit to be washed. When this amount does not justify better equipment, the fruit may be placed in crates and merely hand-dipped in barrels or tanks. A somewhat more expeditious and less laborious method is to dip in a partitioned trough, one-half containing the acid or cleansing solution and the other the rinse water. In each compartment is hinged a covered slat tray with handles

[23] The rinse water should be free from any acid taste or if tested with blue litmus paper show practically no change in color.

[24] These forms of injury are illustrated and described in: Haller, M. H., E. Smith, and A. L. Ryall. Spray residue removal from apples and other fruits. U. S. Dept. Agr. Farmers' Bul. 1752:1–25. 1935.

on one end.[25] The fruit, placed on the tray in the cleaning solution, is raised and lowered in it several times. The top is then lifted, and the tray tilted sufficiently so that the fruit passes into the rinse portion of the trough, where the same process is repeated.

Where larger quantities of fruit are involved and yet the expense of a commercial washer is too great, growers have devised various types of homemade washers operated either by hand or by an electric motor. The simplest of these are known as flotation washers because the fruit, forced along by means of revolving paddles, floats in the solution. In other instances the fruit is carried through the washer on a series of rollers. Cloths, pieces of soft rubber, or brushes hanging in the acid compartment turn the fruit as it passes under them and act as scrubbers. An inclined conveyor dipping into the cleaning solution at the end of the tank carries the fruit over into the rinse compartment, which is equipped with a similar conveyor to lift it out into boxes or on to the sorting belt. These machines, which vary considerably in size and details of design, are simple and relatively inexpensive. Although they lack certain advantages of the better commercial washers, they should prove entirely satisfactory under California conditions. Drawings and specifications for building one type appear in a recent bulletin issued by the United States Department of Agriculture.[26]

Where the amount of fruit justifies the expense, the commercial flood-type washers are best adapted for rapid cleaning. In these machines, some of which have a daily capacity of 2,000 boxes or more, the acid solution and the rinse water are pumped over or sprayed with considerable force upon the fruit as it passes between revolving brushes or is turned by a special type of conveyor. The brush type of washer has proved especially efficient with residues that are difficult to remove.

PACKING[27]

Many of the apples grown in the Pajaro Valley and also in the smaller apple districts are sold as "loose" apples. This fruit, destined for California markets, is sorted and graded, but unwrapped. It may or may not

[25] Illustrated and described in detail in: Cox, Alvin J. Warning to driers of pears, apples, or apple pomace with regard to spray residue. Blue Anchor 11(7):14–15. 1934.

[26] Haller, M. H., Edwin Smith, and A. L. Ryall. Spray residue removal from apples and other fruits. U. S. Dept. Agr. Farmers' Bul. 1752:1–25. 1935.

[27] The following publication has been drawn upon by the author in the preparation of this section: Tufts, Warren P. The packing of apples in California. California Agr. Exp. Sta. Cir. 178:1–31. 1927.

Also for a more detailed discussion of packing and of apple-packing houses see: Pailthorp, R. R., and H. W. Samson. Northwestern apple packing houses. U. S. Dept. Agr. Farmers' Bul. 1204:1–39. 1921.

Pailthorp, R. R., and F. S. Kinsey. Packing apples in boxes. U. S. Dept. Agr. Farmers' Bul. 1457:1–21. 1925.

be faced or arranged in the boxes, but the law forbids packing it according to recognized apple packs. Interstate shipments, on the other hand, must be wrapped and packed to insure successful shipment.

Previously, a considerable amount of packing was done in individual orchards in some temporary packing shed or out-building, the grower and his family doing much of the work. This type of packing has now been largely discontinued, and most growers either sell their fruit loose or haul it to a central packing house. Such houses are usually provided with modern washing and grading equipment; the fruit is carefully graded and packed by experienced helpers. Although packing is a slow operation for the amateur, an expert will wrap and pack 125 to 150 boxes in a nine-hour day. Besides handling the fruit expeditiously and economically, central packing houses turn out a standardized pack for the entire district. Carload quantities of fruit can be sold under a single brand or trademark; and the buyer, who purchases largely according to specifications, can be assured of uniformity.

Grading and Sizing.—After removing any spray residue, the first step in packing is to sort out and discard the cull fruit and to grade and size that which is to be marketed. The former work is usually done by girls or women standing or seated at endless grader belts that carry the apples. These helpers should be able to see defects quickly and, as the fruit passes before them, to classify it according to the proper grade. The provisions of the California Agricultural Code relating to apple standards, state that all apples shall conform to one of the following standards: Extra Fancy, Fancy, Fancy Loose, C Grade, C Grade Loose, and combination Fancy and C. Grade Loose.[28]

To be first or Extra Fancy, the fruit must not only be free from injury but as nearly perfect in size, color, and shape as is possible in commercial quantities. The percentage going into this grade, even in the best years, will therefore be small.

The requirements for Fancy grade apples are in some respects the same as for Extra Fancy. The essential difference is that there are no color requirements and that the law permits slight defects (but not appreciable damage) resulting from limb rubs, spray burn, sun scald, russeting, drought spot, hail, frost, internal browning, or various diseases and insect pests. Fancy grade apples comprise the larger percentage of those shipped and are the basis upon which most California apples are judged. Growers and packers should therefore strive, especially in

[28] Copies of these regulations giving the detailed requirements for each grade may be obtained from the Bureau of Fruit and Vegetable Standardization, State Department of Agriculture, Sacramento, California. The grades given are those revised for 1936.

unfavorable or small-crop years, to grade carefully and not "crowd" the pack by including fruit that belongs in the C Grade.

The C Grade includes apples lacking in normal color and shape or showing appreciable (but not serious) damage from the defects mentioned above. All apples of these three grades must be uniform in size, within limits of ⅜ to ½ inch and, with the exception noted under "Containers and Methods of Packing," may be packed, when wrapped, only in standard-sized containers.

Where apples are not packed as one of these grades they may be graded and sold as Fancy Loose, C Grade Loose, or a combination of the two. Fancy Loose apples must be of the same general quality as Fancy

TABLE 4

DIAMETER MEASUREMENTS AND NUMBER PER BOX OF COMMERCIAL SIZES OF APPLES

Diameter in inches	Number per box	Diameter in inches	Number per box
3⅜	80	2⅝	138–150
3⅜	88	2⅝	163–175
3⅛	96	2⅛	175–188
3	113–125	2⅛	200–216
2⅞	125–138	...	.....

and differ generally only in that they may lack uniformity of size. All specimens, however, must be 2¼ inches in diameter or over.

The C Grade Loose apples conform to the requirement of C Grade except that there are no size restrictions and the fruit does not have to be hand-picked. Gravenstein apples that will not pass through a 2¾-inch ring need not be properly matured to make this grade. In the combination Fancy and C Grade Loose, all Gravensteins shall be mature; and not less than 50 per cent, by count, of apples must meet the requirements for the Fancy Loose grade. There are no restrictions regarding the size or type of container for loose apples when in an open or unlidded container.

Commercial apple packs commonly found on the market cover a range of ten to fifteen sizes, the size in each case being indicated by the number of apples packed in the box. Each size packed varies in its diameter measurements as much as 1/16 to ⅛ inch. In central packing houses and in others equipped with mechanical fruit sizers, the apples are automatically sized to approximately ⅛ inch variation as they drop into the various bins. The packer may further segregate the specimens in each bin into two sizes. Actual dimensions vary slightly with different varieties, but average diameters for the different packs are shown in table 4.

To distinguish the different sizes is the most difficult phase of packing.

For the amateur, who may have to do his sizing by hand, a measuring board of light wood or heavy cardboard in which a series of holes of different sizes are cut will prove helpful in first separating and fixing in mind the different sizes. Continued practice for a few days in picking out the various sizes will soon enable one to recognize them.

Containers and Methods of Packing.—The California Agricultural Code specifies that all *wrapped* apples must be packed in the standard apple box, inside depth 10½ inches, inside width 11½ inches and inside length 18 inches; or in a half apple box 5¼ × 11½ × 18 inches, inside

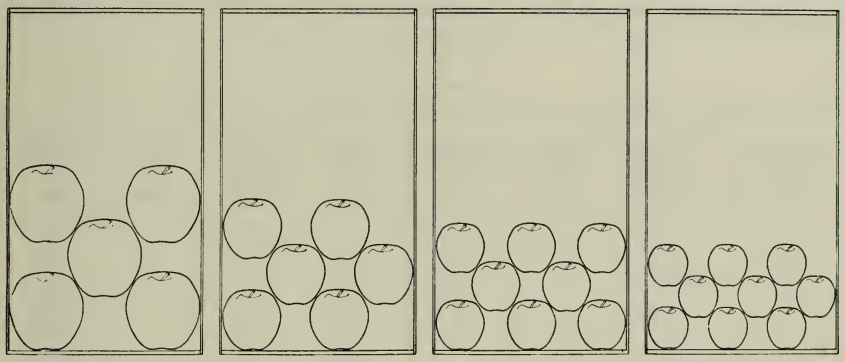


Fig. 12.—Diagrammatic sketch showing method of starting different apple packs: *A*, two–one; *B*, two–two; *C*, three–two; *D*, three–three.

measurement. Smaller packages for wrapped apples than the half box are permissible only where the package is conspicuously marked in letters not less than ½ inch high: "Irregular Container." Wrapped apples are packed almost exclusively in the standard apple box, holding when well packed 44–48 pounds of fruit.

As previously mentioned, there are at present no regulations governing the size or type of container for *unwrapped* and unpacked apples in open containers. Many of the latter are sold either loose or packed (unwrapped) in various types of lug boxes and in paper cartons.

Styles of packs are usually spoken of as the "two–one" pack, the "two–two" pack, the "three–two" pack, and the "three–three" pack (figure 12). These differences in arrangement crosswise the box, with the variation in the number of apples lengthwise and the number of layers, accommodate all the different sizes.

The two–one pack (fig. 12, *A*), containing only three layers, is rarely used, being designed to care for only the largest apples—those so large that when one is placed in each corner of the box the space remaining between them will be approximately only half large enough for a third

apple. Where this space is sufficiently large to permit the three apples but not four in a straight row crosswise of the box, then the two–two arrangement shown in figure 12, *B* should be employed. This style of pack is four layers in depth and will accommodate sizes which are from 48 to 96 to a box. The first layer of this pack is started as shown in the figures given above. The individual fruits in the second and third layer fit in the pockets formed by the apples beneath.

The three–two arrangement, five layers in depth, finds greater use than any other pack because it cares for all the medium and some of the medium to small-sized fruit—usually sizes 100 to 175. This pack should

TABLE 5

APPLE PACKS

Arrangement crosswise	Number of fruits in rows lengthwise	Number of layers in depth	Number of fruits in box	Arrangement crosswise	Number of fruits in rows lengthwise	Number of layers in depth	Number of fruits in box
2–1	4×4	3	36	3–2	5×5	5	125
2–2	3×3	4	48	3–2	6×5	5	138
2–2	4×3	4	56	3–2	6×6	5	150
2–2	4×4	4	64	3–2	7×6	5	163
2–2	5×4	4	72	3–2	7×7	5	175*
2–2	5×5	4	80	3–2	8×7	5	188
2–2	6×5	4	88*	3–3	5×5	6	180
3–2	4×3	5	88†	3–3	6×5	6	198
2–2	6×6	4	96	3–3	6×6	6	216
3–2	4×4	5	100	3–3	7×6	6	234
3–2	5×4	5	113	3–3	7×7	6	252

* For flat apples. † For long apples.

be used with apples where four in line would fill the box crosswise or where, as in figure 12, *C*, the fourth and fifth apples placed in the box cannot slip more than halfway into the spaces formed by the first three placed next to the end. In constructing the pack, the bottom layer is completed by repeating the same arrangement as shown. In the second layer the individual fruits are again placed so as to fit into the pockets formed by the apples beneath. The layer will be started with two apples instead of three. Layers 1, 3, and 5 and layers 2 and 4, will be identical, respectively.

For apples smaller than 175–188, or at least for those measuring less than 2¼–2⅜ inches in diameter, so that five apples would form a straight line crosswise of the box, the three–three pack is generally used. The arrangement for starting is shown in figure 12,*D*. It is continued in similar fashion to the three–two pack except that three apples are used each time across the box. This pack contains six layers, the fruits being placed in the same general manner as already described. Table 5 shows

the general range of sizes and the arrangement of the more common packs.

Liners and Wrapping Paper.—To add a finished appearance and also to protect the apple, lining paper is generally used in packing the better grades. Either the ordinary "white news" stock or special types of colored paper may be employed. Two sheets, 17½ × 26 inches, are placed in each box before packing. These overlap on the bottom and fold over the top after the box is completed. To avoid tearing when the bottom bulge is formed by lidding, an extra fullness must be left at the bottom edges. Besides the liners, boxes of all shipments of Gravensteins for export and some of those for domestic markets carry a top and bottom pad to protect against bruising.

Wrapping the individual fruits aids in packing by holding the specimens in place, reduces bruising, prevents spread of decay, and reduces transpiration losses. It also gives the package a more finished appearance, particularly if each wrap carries the printed brand or trademark under which the fruit is sold. Fruit wraps are now made mostly from light-weight, tough, and usually partly transparent paper. Oil-treated wraps are now largely used where the fruit is to be stored, as a preventive against scald. Apple wraps are usually purchased in 50-pound bundles and can be secured in various sizes to accommodate fruit of different sizes. For extremely large apples, paper 12 × 12 or 14 × 14 inches should be used. For sizes 64 to 80, 11 × 11; sizes 88 to 113, 10 × 10; sizes 125 to 180, 9 × 9; and sizes less than 180, 8 × 8. One-half pound of paper is sufficient to pack a box of average-sized apples, 10 × 10 wraps running approximately 300–325 sheets to the pound.

Details of Wrapping and Packing.—Methods of wrapping vary slightly with different packers, who, as they gain skill, have devised some special system of their own. Figure 13, however, shows the essential steps of one simple and rapid method. In figure 13,*A*, the packer is picking up the wrapper with his left hand and an apple with his right. A rubber fingerstall worn on the forefinger of the left hand aids in picking up the wraps. These are grasped by the forefinger and thumb toward one of the upper corners. The apple is next tossed, stem end up, into the upper half of the wrap held in the left hand, while the right hand, with no lost motion, takes the position shown in figure 13, *B*. The next step is accomplished by continuing the upward movement of the right hand and the turning down of the palm of the left hand (fig. 13, *C*). Wrapping is completed by a rolling over or twisting motion of the left hand (fig. 13, *D*). Little or no wrapping is done with the right hand, its function being merely to afford a solid working surface for the left. In figure 13,*E*,

Fig. 13.—Five steps in wrapping apples. (From Cir. 178.)

the wrapped fruit is being placed in the box by the left hand while the right starts reaching for another apple.

Once learned, wrapping is a simple operation; but the ability to gain speed and to wrap neatly and smoothly, with all the loose ends of the wraps tucked in, can be acquired only through practice and experience. Proper-sized wraps for the fruit being packed should always be used. These are held in convenient positions on a tray or holder on the side of the box.

As indicated in the diagrams of figure 12, showing styles of packs, the apples are always placed in the box on their side with the stem always pointing away from the packer. The spaces between the apples must be kept equal, and the alignment watched. Good spacing and alignment are easily obtained where the specimens are uniformly sized and are not permitted to turn sideways after being placed in the box. Where the fruit is of variable size, however, to make up a satisfactory pack is almost impossible.

Packing continues by placing the apples in the box in regular order until the first layer is completed and the fruit is held firmly in place by the pack. Proper compactness, spacing, and alignment of the first layer is of prime importance, for it governs the arrangement in subsequent layers and the total number of apples that must comprise the pack. The second and subsequent layers are constructed like the first by placing the apples in the pockets formed for them by the specimens beneath. Never allow an apple to be forced out of these pockets; the result will be a "broken" and irregular pack.

During transportation or storage, fruit shows slight shrinkage. To insure against the specimens' becoming loose and bruised, apple packs are constructed with a bulge of about 1½ inches, which after lidding is about equally divided between the top and bottom of the package. This extra height of the apples in the center of the box may be secured either by pulling the center specimens in each layer slightly closer together than those at the ends, which makes the pockets smaller and increases the height of subsequent layers; or by packing the apples near the center of each layer in the box so that their longest crosswise diameter is perpendicular to the bottom of the box. Conversely the specimens in the first and last two rows at the ends should be turned with their shortest diameter in this direction. The ends of the completed pack should not extend more than ¼ to ⅜ inch above the ends of the box. This fruit is, of course, forced down more closely into the pockets beneath when the box is lidded.

Difficulty is frequently experienced in getting the pack to finish at the proper height; packers must learn just how tight to pull the apples in

each layer in order to build a perfect pack. The looser the pack the higher it may be built without bruising the apples when the box is lidded. Also the larger the apples in any given style of pack, the more loosely they should be placed in the box. Apples of sizes 100 and 175 are both packed in five layers according to the 3–2 arrangement, but in order to secure the proper height the smaller apples must be drawn closer together as packed.

Not only should the top layer of the pack come to the proper height in the center and at the ends, but the entire surface should be regular and even. Any individual specimens standing higher than those adjacent are subject to bruising or cutting as the lid is pressed down and nailed in position.

Stamping and Labeling.—As the packed boxes reach the nailing press, before lidding, the nailer or some other designated person must stamp the following information on one end of the box: variety, grade, number of apples in the box (within 5 of the true count), date of packing, and either the minimum net weight of the apples or the cubical contents of the box. The box must also show the name and address of the person authorizing the packing or the number under which such packer is engaged in business. This information usually appears on the lithographed label pasted immediately under the stamped information. Different labels or different color combinations show the brand under which the fruit is packed and serve as a useful means of identifying the grade. Well-chosen lithographing also lends attractiveness and aids in advertising. Packed apples held in cold storage for more than thirty days must be so marked.

According to present requirements, open containers of apples that are not packed (arranged) need show only the grade and name and address of the person who first placed or authorized the placement of the apples in them.

STORAGE

Although little of California's Gravenstein crop harvested in July finds its way into storage, a large share of the later varieties must be held throughout the winter. The Yellow Newtown, grown in the Pajaro Valley, is stored most extensively. Local storage can care for approximately 1,400,000 boxes. In addition, part of the crop may be stored for short periods in the commercial cold-storage plants of the larger consuming centers. Such plants must also care for that portion of the fruit which is stored from the smaller producing districts.

Types of Storage.—The most efficient type of storage for long holding is the "cold storage," where low temperatures are secured and maintained

by mechanical means. The rooms are cooled by the direct expansion of ammonia in coils on the walls or beneath the ceiling, by air circulating through the room and then over coils or through a brine spray in a bunker room, or by a combination of the two systems. In the newer plants, including the smaller individually owned houses, the air-circulating system is employed. A good circulation of air and some provision

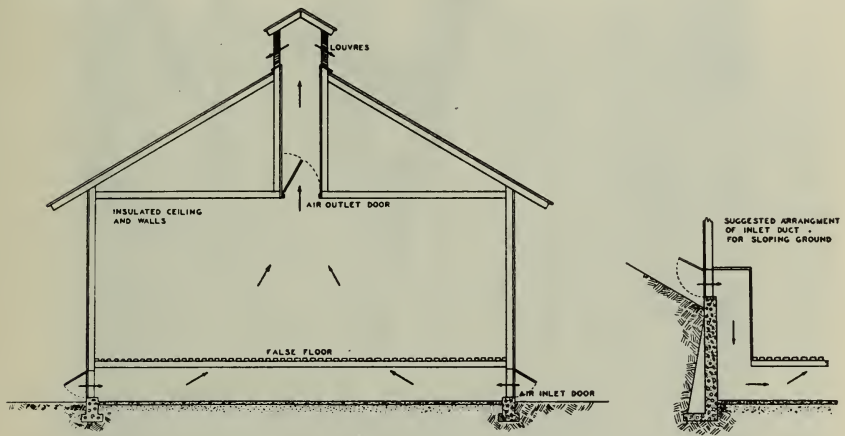


Fig. 14.—Diagrammatic cross section of air-cooled storage house showing general type of construction for maximum air circulation and most satisfactory air temperatures. Vents are opened at night and closed during the day or whenever the temperature inside the house is below that of the outside air.

for ventilating are desirable both for cooling large blocks of warm fruit quickly and for keeping the room relatively free from odors and noxious vapors.

Small automatic refrigerating units, similar in their operation to a mechanical refrigerator, are an innovation for ranch storage houses. The possible advantages of such a house over a centrally located commercial or coöperatively owned plant at trackside will be governed by such factors as the relative cost, including the original investment and overhead charges, the amount of fruit to be stored, and the general convenience in relation to washing, packing, and other handling operations. Occasionally where an individual purchases and packs fruit in addition to what he himself produces, such storage houses have been constructed in connection with the packing house.

In addition to refrigerated storages, many Northwest apples are successfully held for a number of months in ventilated or "air-cooled" storages constructed either aboveground or underground. Such houses may be used with considerable success in sections of California where night temperatures at harvest time and thereafter drop relatively low. All air

intakes and outlets of the house are opened each evening, a free circulation of air is allowed during the night, and then all ventilators are closed the following morning as the outside temperature rises above that in the house. This type of house is most efficient where the intake air in above-ground houses is brought in at the ground level and the fruit is stored

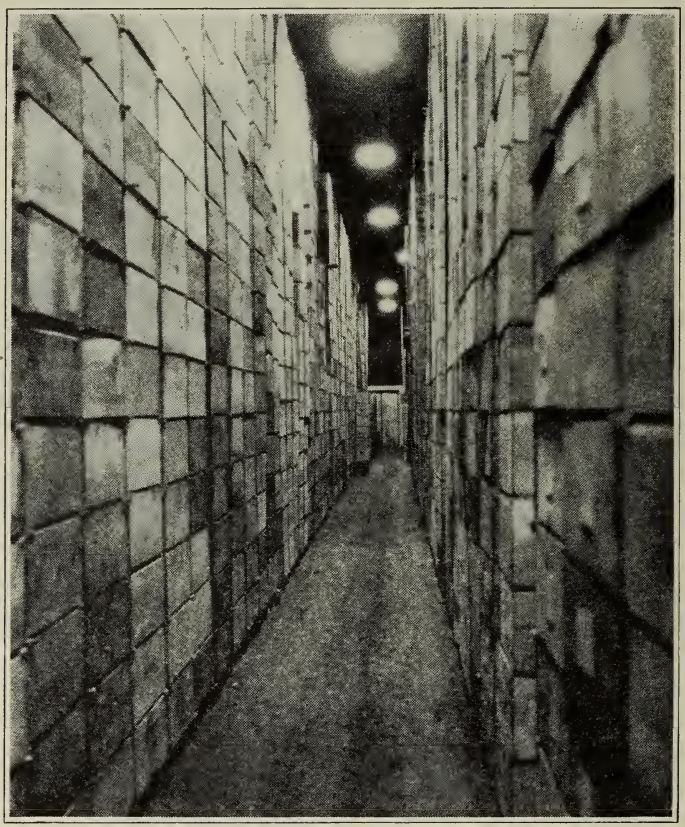


Fig. 15.—Interior view of a large cold-storage room at Watsonville, showing method of stacking boxes of loose apples.

on an open floor, constructed of 2 × 4's, some 18 inches above the ground. The vents for the outgoing warmer air should be overhead and should extend for a short distance above the roof of the building. Such a construction insures the maximum amount of draft through the house for cooling. In basement storages, doors may be used for air intakes; or the incoming air should be conducted from the ground level to the floor of the cellar or basement through wall flues (fig. 14).

If water is available, shriveling of the fruit may be reduced by keep-

ing the soil wet beneath the raised floor. If the fruit is to be held during freezing weather, aboveground houses must be constructed with insulated walls and ceiling, or some provision must be made for heating.

Methods of Storage.—With the Yellow Newtown known as the chief storage variety and largely sold on local markets as unpacked fruit, most California apples are stored loose in open boxes. Except occasional small

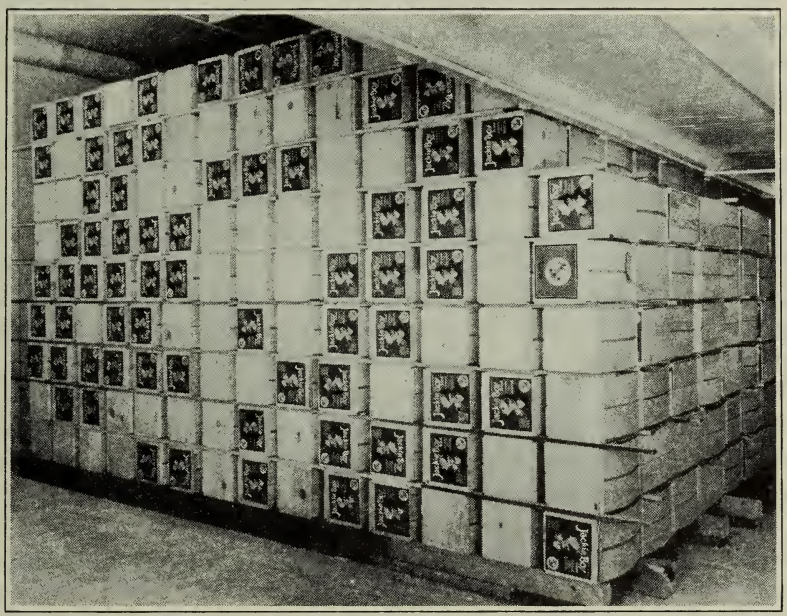


Fig. 16.—Interior view of cold-storage room, showing method of stacking packed Gravensteins awaiting export shipment. (Courtesy of the California Fruit Exchange.)

lots from the lesser districts, only Gravenstein and Yellow Newtown apples awaiting export shipment are stored wrapped and packed.

Loose fruit in open boxes and fruit in boxes packed and lidded are stored differently, primarily in that the former must be stacked in an upright position and at least one-third more storage space is required to accommodate an equal amount of fruit. To handle large quantities of bulk fruit the cold-storage plants in Watsonville contain rooms with sufficiently high ceilings to permit stacking 18 to 20 boxes high. This arrangement necessitates much extra handling, for the stacks are built in steps, and the fruit must be passed up from one to the other. Packed boxes, always stored and handled on their side to prevent damage on the bulged top and bottom, are usually stacked low enough to be lifted by a man standing on the floor or a low platform.

Whether packed or loose, the stacks should be raised 4 to 6 inches from the floor by placing the bottom boxes on properly spaced timbers. Individual stacks in large blocks of fruit, especially if packed, should be separated by a small air space. The boxes in individual stacks are also separated, and the stacks held firmly in place by dunnage strips. Figures 15 and 16 illustrate typical methods of stacking loose and packed fruit.

Storage Conditions Influencing Keeping Quality.—Three storage factors may be mentioned as important in maintaining apples in good condition: a low temperature, a high relative humidity, and an atmosphere kept free of noxious odors or gases.

A low temperature is the most practical and effective means of retarding ripening. For holding apples for the maximum period of time a temperature of 31°–32° Fahrenheit (2½° to 3° above the freezing point) has long been recommended for most apple varieties. Experience with Yellow Newtowns grown in the Pajaro Valley has shown, however, that this variety is subject to a low-temperature injury known as internal browning; and to reduce this injury a temperature of 36° is recommended.

Investigators at the Iowa Agricultural Experiment Station[29] are also recommending a temperature of 35°–36° Fahrenheit for apples picked at proper maturity and carefully handled. They have found that this higher temperature has resulted in better flavor and color.

Although low temperature is effective in holding ripening changes to a minimum, apples removed from storage after being held for a considerable period may show a certain sponginess and may lack crispness. This condition is due to excessive moisture loss from the fruit through transpiration and may be prevented by maintaining a high relative humidity in the surrounding air. Since a relative humidity of 85 per cent gives fairly satisfactory results with wrapped fruit, this percentage of saturation has generally been recommended. At present, however, more experimental work is being done to determine optimum humidities more accurately; and it seems safe to state that apples in cold storage at 32° Fahrenheit will remain more firm and crisp if held in an atmosphere of 90 to 95 per cent saturated. At air-storage temperatures of 45°–60° this higher humidity may render the fruit somewhat more susceptible to attack by various rots; but if all damaged specimens are sorted out before storage and the fruit is held in clean boxes, decay should be slight. Regardless of storage conditions all stored fruit should be inspected at various intervals to determine its keeping quality.

[29]Plagge, H. H., T. J. Maney, and B. S. Pickett. Functional diseases of the apple in storage. Iowa Agr. Exp. Sta. Bul. 329:1–79. 1935.

Besides being benefited by cold, moist air, apples are much less likely to develop scald (see discussion of storage troubles) where the atmosphere surrounding them is kept relatively free from the odorous vapors they give off. Oiled wraps that absorb such toxic vapors are one means of reducing scald. Such wrappers have given, however, only indifferent results with Pajaro Valley Newtowns; and unwrapped fruit held in rooms receiving good circulation and adequate ventilation are likely to be most free of this trouble. Unventilated rooms in which large quantities of fruit are stored may have an atmosphere containing several per cent of carbon dioxide. Carbon dioxide in itself, however, is not apt to become so concentrated as to prove harmful. Its action in reducing respiration has, under some conditions, in fact proved decidedly beneficial in maintaining the fruit firm and (in green varieties) of its original color. Numerous commercial storages are in operation in England for holding apples in atmosphere containing 5 to 10 per cent carbon dioxide, and the possible advantages of this method for California are now being studied.

Other Factors Influencing Keeping Quality.—Failure of fruit to keep well in storage may or may not be the fault of the storage operator. The warehouseman's responsibility is to supply proper temperature and air conditions and to take immediate steps to correct any trouble. Even under optimum storage conditions, however, apples sometimes fail to keep well; and in these instances the trouble must result from some inherent weakness in the fruit itself due to conditions under which it was grown or to the time of picking and the manner of handling before storage.

The time of harvesting for storage and the method of handling before delivering to the storage are the grower's responsibility; not infrequently, poor keeping quality can be traced to injudicious harvesting or handling. Apples allowed to remain on the tree too long tend to break down and to become mealy in storage. This fact, however, does not justify the conclusion often drawn that early-harvested apples will keep better than those allowed to become riper. The determining factor is the actual degree of maturity at harvest. Immature fruit will not break down and become mealy, but it is subject to shriveling and to scald and will fail to ripen with its characteristic color or flavor. For optimum storage, apples should be harvested at maturity and not before. (See section on tests for maturity.)

After being harvested, apples should be hauled in, cleaned, graded, and placed under storage temperatures with the least possible delay. Although the damage is not apparent at the time, allowing fruit to stand in the orchard or even the packing house for several days may mate-

rially shorten its storage life. Any rough handling resulting in bruises, skin punctures, and the like will also be reflected later in storage. Washing in hydrochloric acid of the strength previously recommended should not, with proper rinsing, injure the keeping quality.

Storage Periods for California Apples.—The period of greatest consumption for the leading California varieties is given under the variety descriptions. Few varieties except Yellow Newtown and Yellow Bellflower are stored in quantity. Yellow Bellflower may be kept until November or December or even later, though such practice is usually unprofitable. Yellow Newtowns have a variable period of storage depending somewhat upon their susceptibility to internal browning. Some fruit should not be stored longer than two or three months, whereas that from other orchards may be held until May. Gravensteins, if well matured when harvested, may keep very well for several months but are rarely stored because of meeting better sale in July and August. The general storage period for other varieties held at 32° F are Jonathan, White Pearmain, Tompkins King, Spitzenberg, and Delicious, four to five months; Rome Beauty, five to six months; and Winesap, seven to eight months.

Where apples are stored their season will naturally be much shorter, the length of their storage life largely depending upon the temperatures maintained. Quantities of apples held for commercial use should never become full eating ripe before leaving storage. Late in the season the fruit will ripen very rapidly at the higher outside temperatures and may become overripe or develop scald or other trouble before it can be sold and used.

STORAGE AND MARKET DISEASES[30]

The life of apples in storage may be terminated by the general internal breakdown of old age, or by some physiological disease or fungus rot. A few of these troubles will be briefly mentioned.

Internal Breakdown.—Internal breakdown is associated with a general overripe condition and marks the end of the storage life of fruit not otherwise affected. Apples lose their firmness and juiciness; the flesh becomes dry and mealy—in severe cases soft and brown. The disease, which is sometimes mistaken for freezing injury, most often first occurs on large-sized overmature fruits. Late harvesting, delay in storage, and high temperatures all favor its early development. The amount and seriousness of the trouble varies from year to year, being influenced by

[30] For a more complete discussion of storage troubles see: Rose, Dean H., Charles Brooks, D. F. Fisher, and C. O. Bratley. Market diseases of fruits and vegetables—apples, pears, and quinces. U. S. Dept. Agr. Misc. Pub. 168:1–70. 1933. This publication has been drawn upon in the preparation of this section.

growing conditions. Naturally internal breakdown appears sooner and is more serious in fruit held in air-cooled storage houses than in cold-storage fruit.

Bitter Pit.—Bitter pit, which occurs in all important apple-growing regions of the world, is particularly important in California on the Gravenstein variety. Early-picked fruit showing no signs of the disease when packed may be badly infected 10 days later when it arrives on the

Fig. 17.—Bitter pit in Gravenstein apples.

eastern markets. Bitter pit also frequently appears in less severity in storage on Yellow Bellflower, Yellow Newtown, Winter Banana, Delicious, and other varieties.

As illustrated in figure 17 the disease is characterized by small sunken spots, largely concentrated over the blossom end of the apple. At first these appear as water-soaked bruiselike spots on the surface, later turning dark green (on green apples). Finally, as the disease advances, they become depressed or sunken into definite pits of regular outline that take on a brownish color. When the skin is removed, the dead brown pulp cells appear in the flesh. Although these areas are associated with the ends of the vascular system of the fruit, they may appear throughout the flesh.

Bitter pit is a physiological or nonparasitic disease. Investigators have advanced numerous theories as to its origin without entirely proving any. Certain individual facts, however, are known and are helpful in reducing losses. Generally speaking, the trouble is worse on fruit from

young trees than on that from older trees; worse on large fruit than on small; worse in years of light crops, or heavy rainfall, or late irrigation. Fruit picked immature suffers much worse than fruit picked well matured. Apparently, therefore, certain factors influencing the nutrition and water supply during growth and early ripening have an important bearing upon bitter pit development, and the severity of the disease may be reduced by orchard practices tending to promote uniform crops and tree growth and by harvesting only mature fruit.

As growing conditions vary somewhat from year to year, a seasonal difference is likewise often seen in the development of bitter pit. There is some evidence that the fruit from certain trees is more susceptible than that from others.

Immediate storage of apples at cold-storage temperatures will retard but not prevent bitter pit. In fact, fruit ripened after storage at a low temperature seems to develop more pitting than that ripened immediately at 70° Fahrenheit. Bitter pit does not spread from one apple to another in transit or in storage.

Internal Browning.—Internal browning is another physiological trouble apparently due to certain abnormal nutritional conditions in the tree that affect the fruit. It has little or no economic importance outside the Pajaro Valley, but in that section it is the most important trouble affecting the Yellow Newtown. Except in advanced stages the trouble is not apparent from any abnormal external appearance of the skin, and the fruit must be cut to determine its presence. A softening at the basal end of the apple around the stem, however, is an indication of severe browning.

The disease is first noticeable usually in December or January; then, when the apple is cut in cross section, one-third the distance between stem and blossom end, more or less elongated and slightly discolored areas radiate outward from the central portion. At first the discoloration is only slight, and the areas are adjacent to the primary vascular bundles. As browning becomes more severe, however, they spread rapidly to the secondary bundles, and finally the condition may become more or less general (fig. 18). When the disease reaches its worst stage the thick-walled cells of the epidermis turn brown and the fruit appears as though infected with scald. In some instances browning may be confined largely to the core region, this sometimes being designated as "core browning" to distinguish it from the more usual form.

Both state and federal investigators who have worked on the problem find that the conditions which produce browning in the Pajaro Valley are closely associated with a relatively low growing temperature and

a high humidity, climatic conditions characterizing that section. The browning is generally worse in fruit from the valley floor, where these conditions are coupled with a fertile heavy type of soil. Fruit grown in the hill sections is less susceptible and frequently shows no browning.

Winkler,[31] by experimental means, developed fruit under temperatures both above and below the normal. Where the mean daily temperature was raised approximately 4° C above normal, little browning occurred, whereas with a similar decrease in temperature 95 per cent of the speci-

Fig. 18.—Internal browning of Yellow Newtown apples. Left, severe browning; right, normal apple.

mens showed more or less browning. As these results indicate, browning throughout the district should be more severe in years of low summer temperatures. According to the popular belief, this is true; yet other factors frequently mask or nullify the results of variation in temperature. During the past few seasons results have been secured on the amount of browning in ten different orchards, and the severity of the trouble could not well be correlated with mean growing temperatures. One orchard has consistently produced fruit extremely susceptible to browning each year whereas others near by have shown much less of this trouble. A considerable variation is found not only between different orchards but between different trees growing close together.[32]

Ballard reported that browning was much worse in large fruit and in

[31] Winkler, A. J.. A study of the internal browning of the Yellow Newtown apple. Jour. Agr. Research 24(2):165–84. April 14, 1923.

[32] These observations of the writer confirm the results reported in the following: Overholser, E. L., A. J. Winkler, and H. E. Jacob. Factors influencing the development of internal browning of the Yellow Newtown apple. California Agr. Exp. Sta. Bul. 370:1–40. 1923. (Out of print.)

Ballard, W. S., J. R. Magness, and L. A. Hawkins. Internal browning of the Yellow Newtown apple. U. S. Dept. Agr. Bul. 1104:1–22. 1922.

light crop years and that heavy thinning and fertilizing tended to increase its severity. Overholser, Winkler, and Jacob found the size of the crop to be an influencing factor but fruit both from weak and from excessively vigorous trees to be more susceptible to browning than that from trees of normal vigor. More browning was also found in apples from old trees than in those from young ones. Numerous factors relating to growth seem, therefore, to be involved.

Picking and storage practices are also an influence. The writer's results have confirmed those of the previous investigations in that the severity of browning increases somewhat with the maturity of the fruit. Of all the factors influencing the development of browning, however, storage temperature is the most important. Fruit from trees known to be susceptible will not brown if held at 45° Fahrenheit and will develop much less of the trouble at the recommended storage temperatures of 36°–38° than at 32°. Browning increases rather rapidly after the fruit is removed from storage.

The real cause has not definitely been determined. Winkler and his associates believe that browning is closely related to apple scald and that its probable cause is the accumulation of essential oils or other deleterious substances produced by the apples in storage. From their preliminary tests, ventilation of storage rooms and sometimes use of oiled fruit wraps appeared advantageous.

Scald.—Apple scald (fig. 19) is one of the most serious and widespread storage diseases. Unlike internal browning it occurs in all apple sections and on most varieties, among which Arkansas (Mammoth Black Twig), Grimes Golden, Rome Beauty, Rhode Island Greening, Wagener, Stayman Winesap, Winesap, and Yellow Newtown are highly susceptible. Scald is primarily a skin disease, which in mild cases appears as a superficial browning. On red varieties it is confined primarily to the greener side of the fruit. In severe cases the entire surface may become discolored and separate from the pulp. Occasionally in the later stages the flesh may likewise become brown to a depth of ¼ inch or more.

The immediate cause of scald, according to federal investigators,[33] is the accumulation, within the apple tissues, of certain gases or vapors (other than carbon dioxide) given off by the apples themselves as a result of respiration. This being true, the remedy is to remove these gases by providing sufficient air circulation and ventilation in storage or else to

[33] Brooks, Charles, J. S. Cooley, and D. F. Fisher. Apple scald and its control. U. S. Dept. Agr. Farmers' Bul. 1380:1–16. 1923.

Rose, Dean H., Charles Brooks, D. F. Fisher, and C. O. Bratley. Market diseases of fruits and vegetables—apples, pears, quinces. U. S. Dept. Agr. Misc. Pub. 168:1–70. 1933.

absorb them by means of oiled fruit wraps. The latter method is generally recommended for packed fruit which is to be stored. In California, as previously stated, most Yellow Newtowns are stored loose. Unwrapped fruit shows decided less scald than wrapped; but where large quantities are tightly stacked, cooled slowly, and held at a minimum temperature of 36° Fahrenheit, conditions favor scald development. Slight scald in

Fig. 19.—Apple scald of Yellow Newtown apples.

storage is apt to become serious within a few days after the apples are removed.

Storing at 32° Fahrenheit is not advisable with Pajaro Valley Newtowns because the fruit shows much more internal browning at this temperature. More open stacking, however, and good air circulation that permits more rapid cooling, once the fruit is in storage, together with some ventilation during the first month or six weeks, are recommended practices.

Aside from rapid cooling, low temperatures, and good ventilation in the storage room, the time of harvesting, and cultural and handling methods have a bearing upon scald development. Immature fruit and poorly colored red varieties are particularly subject to scald, and this susceptibility is intensified by delays between the time of harvesting and of placing in storage and cooling. Apples from heavily irrigated trees

have also been found by federal investigators to be much more subject to scald than those irrigated moderately.

Soft Scald.—Soft scald differs from that described above in that the affected areas are depressed and well defined. The browning of the skin and flesh is characterized by a sharp demarcation between the diseased and healthy tissue. The spots vary in size from ¼ inch or less in diameter to rather large areas covering a considerable portion of the surface. The flesh beneath such areas is usually soft, spongy, and moist, but may become dry and collapsed. The disease occurs less frequently than ordinary scald but may sometimes cause serious losses on such varieties as Rome Beauty and Jonathan.

Soft scald is believed to result from abnormal respiration of the apple at low temperatures and is greatly increased by any delay in getting the fruit into storage. Plagge,[34] Maney, and Pickett recommend a storage temperature of 36° Fahrenheit rather than 32°, whereas Rose and his coworkers found that no injury occurred at 32° where the fruit was previously exposed for two days during cooling in an atmosphere containing 20 to 30 per cent carbon dioxide. The oiled wrappers ordinarily recommended for scald will not control this disease.

Jonathan Spot.—Jonathan spot is another skin disease often prevalent on storage apples in many apple sections but confined largely to the Jonathan variety. The spots are at first brown or blackish, very slightly sunken, roughly circular, and from 1/16 to ⅛ inch in diameter. Later they may increase in size or coalesce. In the early stages the spotting is confined to the color-bearing cells of the skin; but after the skin is killed, underlying tissues may become affected. Spotting is most severe on highly colored specimens. The cause of the disease is unknown. Immediate storage, however, reduces its severity.

Water Core.—Water core is an orchard trouble that develops in fruit ripening on the tree. It is recognized by hard, glassy, water-soaked areas, usually near the core or main vascular bundles. In severe cases, however, most of the flesh may be affected, and the symptoms may be visible at the surface. Although found in many regions, water core is most severe in those of intense heat and sunlight. It is associated with mature or overripe fruit and is common in Yellow Transparent, Early Harvest, Jonathan, Delicious, Stayman Winesap, Winter Banana, Arkansas, Winesap, and Yellow Newtown. Partial control may be obtained by avoiding excessive exposure of the fruit to sunlight and by picking it before it becomes overmature. Where present in only a mild form, the trouble may

[34] Plagge, H. H., T. J. Maney, and B. S. Pickett. Functional diseases of the apple in storage. Iowa Agr. Exp. Sta. Bul. 329:1–79. 1935.

disappear in storage. Severe water core may shorten the life of the fruit by rendering it more susceptible to internal breakdown.

Fungus Rots.—Numerous fungus rots may shorten the life of apples in storage, but the most common and destructive is the blue mold rot (*Penicillium expansum*). This attacks the fruit through the lenticels, breaks in the skin, and soon produces soft, watery, light-brown spots of variable sizes. These enlarge rapidly and produce small patches of whitish spores, which soon become more numerous and change to the characteristic bluish-green color, whence the name blue mold. Blue mold occurs primarily in storage, and its development is hastened by a combination of high temperature and high humidity. Handling of the fruit in clean boxes and avoidance of skin breaks will do much to prevent rot losses.

Freezing Injury.—Cold-storage warehousemen watch their storage temperatures so closely that freezing injury rarely occurs. Before apples are injured from this cause the temperature must drop to 29.5° Fahrenheit or below and remain there for several hours. Moreover, even though the flesh may contain some ice crystals the fruit may subsequently fail to show freezing injury. Water-soaked bruises are not a sure sign of freezing. Usually the best indications are the discoloration of the fibrovascular bundles and the threadlike fibres extending throughout the flesh. This coloration may easily be observed in the cross section of frozen apples provided freezing has not been so severe as to result in complete discoloration. In extreme cases all the flesh may become either dry and mealy or brown and water-soaked in appearance.

Such specimens as these may closely resemble those in the advanced stages of internal breakdown. Unless the fruit is known to have been subjected to freezing temperatures, the trouble is difficult to identify with certainty. Apples that have been only slightly frozen may be thawed out with little aftereffect. Frozen apples, however, should not be handled, for any bruising may result in soft watery areas, frequently extending deep into the fruit. The conclusions of different investigators as to the influence of the rate of thawing upon the amount of damage have not been consistent. Perhaps, however, most of the evidence agrees with the popular opinion that less injury is likely to occur where frozen apples are thawed at a temperature below 40° Fahrenheit.

SHIPPING AND MARKETING OF FRESH APPLES[35]

Seasons and Markets.—Early-summer varieties of apples and others picked green to supply a limited local demand for cooking apples move to market in June. The Gravenstein immediately follows in July and August. This variety is packed and shipped east in refrigerator cars. Considerable quantities are also loaded on vessels in San Francisco for English and South American markets. Total shipments vary considerably in different years, the annual average being about 1,200 cars.

The Yellow Bellflower variety supplies local markets from September until November or sometimes later, whereas the Yellow Newtown finds its best sale from December to April. Some of the latter variety is packed and fills a demand of the English trade. The bulk of the crop, however, as well as all the Yellow Bellflowers find their best market within the state. Practically all the fruit moves by truck.

Methods of Sale.—Methods of sale vary considerably in different districts. They may, however, be divided into personal sales and sales made through various selling organizations. Personal sales include (1) sales in which the grower deals directly with local dealers or consumers, (2) sales to cash buyers or representatives of marketing organizations, and (3) orchard sales to buyers who estimate the crop and offer a lump sum for the fruit on the trees.

Selling on local markets, especially those near large cities, is desirable where there is sufficient demand and the grower has the time and inclination to make his own contacts. This personal method is now followed by numerous Watsonville growers, who not only produce their own fruit but specialize in its marketing. A more simple method is to sell at the orchard to cash buyers, who may do their own handling and in some instances their own picking, cleaning, and grading. A certain price may be agreed upon for a definite quantity of a given grade, or the entire crop may be sold orchard run. In the Watsonville district the latter method is popular; not infrequently sales may be made some time before harvest merely by estimating the size of the crop.

Though such sales relieve the grower of all the details of marketing, they are not without their disadvantages. In years of a large crop, cash buyers may be relatively few, and the price low. Buying on crop-estimate basis is so risky that the buyer is justified in making only a low offer.

[35] For details of marketing and distribution of apples see:

Stokdyk, E. A., H. E. Erdman, Charles H. West, and F. W. Allen. Marketing California apples. California Agr. Exp. Sta. Bul. 501:1–151. 1930.

Park, J. W. Market distribution of car-lot shipment of fruits and vegetables in the United States. U. S. Dept. Agr. Tech. Bul. 445:1–30. 1934.

Park, J. W., and R. R. Pailthorp. Marketing apples. U. S. Dept. Agr. Tech. Bul. 474:1–82. 1935.

A further disadvantage of having the buyer do the harvesting is that pickers may be employed on a box basis and may damage fruit spurs and limbs of the tree. In addition, grading and packing by such buyers does not always advance the reputation of the district for a high-quality product.

Where fruit is produced in large quantities for the general markets, the average grower must depend upon some marketing agency, either private or coöperative. These organizations have in the larger eastern markets their own sales representatives, men thoroughly familiar with market conditions and the general demands of the trade. Private sales agencies may purchase the fruit outright or sell on commission. Coöperately owned marketing associations cannot guarantee to the growers—who are the owners—larger returns than might be secured through private agencies, but they have numerous possibilities for making marketing more successful.[36] Several such organizations operating their own packing houses sell a large proportion of the Gravenstein crop.

DRIED APPLES[37, 38]

Importance.—Unlike most California dried fruits, dried apples are produced as a by-product of an industry that grows its crops primarily for fresh shipment. However, as a secondary outlet, commercial driers have utilized a substantial proportion of the California apple crop for a good many years. Drying is the most important outlet for apples that cannot be satisfactorily marketed as fresh fruit because of low quality, inadequate transportation facilities, or inadequate demand for fresh consumption.

Although California ordinarily produces only 5 to 6 per cent of the United States apple crop, it has contributed over 45 per cent of the national total of dried apples in recent years. The dried output of the state averaged about 11,000 dry tons during the years 1931–1935, utilizing approximately 36 per cent of the total apple crop of the state. The dried output has varied from 9,000 to 13,000 tons in recent years, requiring an average of about 80,000 tons of apples in its manufacture.

[36] Erdman, H. E., Possibilities and limitations of coöperative marketing. California Agr. Exp. Sta. Cir. 298:1–19. 1925. (Out of print.)

[37] The paragraphs on the importance of the California dried-apple industry were written by S. W. Shear, Associate Agricultural Economist, Giannini Foundation of Agricultural Economics. The rest of this section on dried apples and those following on canned apples and apples put up for bakers were contributed by E. M. Mrak, Research Assistant in the Division of Fruit Products.

[38] For additional information see: Caldwell, Joseph S. Evaporation of fruits. U. S. Dept. Agr. Dept. Bul. 1141:1–62. 1923.

Cruess, W. V. Commercial fruit and vegetable products. p. 392–394. McGraw Hill Book Co., New York City. 1924.

The drying industry is largely centralized in the Pajaro Valley and in the neighborhood of Sebastopol. In recent years these two districts have each produced about the same quantity of dried apples. About a decade ago the Pajaro Valley normally produced at least 60 per cent of the total dried-apple output of the state. However, apple production in that district has shown a downward trend, while the percentage of the crop utilized for drying has also decreased. At the same time there has been a marked upward trend in the production of Gravenstein apples in the Sebastopol district, accompanied by a big increase in the tonnage dried. As a result of these opposite tendencies in dried-apple production in these two principal districts of the state, the proportion of the dried output contributed by the Pajaro Valley has decreased, while the percentage from the Sebastopol district has increased.

Since about 1929 the Pajaro Valley has usually supplied about 50 per cent of the state dried-apple output, the Sebastopol district roughly 45 per cent, and other areas, chiefly Mendocino and Humboldt counties, only about 5 per cent of the total. The dried-apple output of the Sebastopol district has averaged about 5,000 tons during the past ten years, that from the Pajaro Valley a few hundred tons more. Large crops together with depressed demand for the fresh fruit have resulted in about one-half of the Gravenstein crop being dried in recent years. An even larger percentage of the late apple crop of the Sebastopol district is dried.

Fruit Suitable for Drying.—Apples of almost any variety, size, and condition may be used for drying. An attractive product, however, can be secured only from suitable fruit. Exceedingly small apples are expensive to prepare, produce a low-grade product, and may be better utilized for other purposes. Apples of regular shape are preferred because they minimize labor and loss in peeling and trimming. A fine texture also reduces preparation losses and gives a better appearance. Yellow or green varieties are preferred to red, since traces of such skin left on the fruit in peeling are less noticeable. The color of the flesh may be either white or yellowish, trade preference on this point being divided. Varieties that tend to hold their light color when dried are preferable to those that darken rapidly.

Variety Preferences.—From the standpoint of drier operators the variety preference is probably, in the order named: (1) Yellow Newtown, (2) Rhode Island Greening, (3) Gravenstein, (4) Bellflower. This arrangement includes, of course, only the more common drying varieties. Others often used for drying are Pearmain, Jonathan, Wagener, Hoover, and Rome Beauty.

The Yellow Newtown is perhaps the most extensively dried, gives the largest yield per ton of fresh fruit, slices well without undue breaking, dries with a uniform color, and holds its color well in storage.

Rhode Island Greening gives almost as large a yield as the Yellow Newtown and produces large slices drying a golden yellow. Because of its large core, however, core remains are more apt to appear in the finished product.

The Gravenstein is popular largely because its early ripening permits the producer to take advantage of opening prices and start drying earlier in the season. It dries a cream yellow but tends to discolor badly in storage unless well sulfured. The yield per ton of fresh fruit is about 80 per cent of the yield secured from Yellow Newtown or Rhode Island Greening.

Yellow Bellflower, a soft apple, when mature bruises badly in handling. During preparation the slices break, and it is difficult to get a large percentage of rings with power machines. This variety is better adapted, therefore, and more popular for the production of quarters than slices. The yield per ton is less than from Yellow Newtown or Rhode Island Greening but is better than that from Gravenstein. The color is light, but because of bruising of the green fruit it may not be uniform.

Preparation of the Fruit.—Peeling and coring are done by machines, which may be either hand or power-operated. Experienced operators accomplish more with the power machines, but beginners are apt to injure the fruit by improper coring. Some operators maintain, furthermore, that power machines are not satisfactory for apples with a soft texture or a large core. All machines require constant care and adjustment for the size of the fruit being peeled. After peeling and coring, the fruit always needs to be trimmed as it passes along the inspection belt. Any skin left on the surface, any worm holes, decayed spots, bruises, or other blemishes should be removed.

Cutting is done by machine after peeling and trimming. The fruit may be cut into slices, quarters, sixths, eighths, or small cubes.

Sulfuring.—Sulfuring may be done either before or after cutting. Sulfuring before cutting quickly arrests the tendency to darken; and since whole apples do not pack together, the sulfuring may be more uniform than in sliced and heavily piled fruit. It has the disadvantage, however, that the fresh surfaces exposed by subsequent cutting are somewhat more susceptible to oxidation and darkening and that the workers in the plant dislike to cut the fruit after sulfuring rather than before. If the fruit is sulfured before cutting, the work is best done on moving-slat belt conveyors passing through a sulfur chamber. The length of the sulfuring

period is determined by the length of the chamber and the speed of the belt. The fumes of burning sulfur are introduced from a stove placed outside the chamber and should pass through the chamber in a direction opposite to that of the fruit. To control the flow of fumes, forced draft may well be used. The escape of fumes should be prevented.

Sulfuring after cutting permits of greater uniformity if the fruit is quartered or cubed. Some driers dip the fruit in 2 per cent salt solution immediately after peeling to prevent discoloration before sulfuring. Some convey the fruit for 10 to 15 minutes through a bath of 1½ to 2 per cent sodium sulfite solution in place of sulfur smoke, though the smoking is almost universally preferred. In sulfuring, the cut fruit is placed on trays and exposed to the fumes in an ordinary sulfur house where the sulfur is burned in pans, pots, or pits.

The quantity of sulfur used per gross fresh ton of fruit ranges from 1½ to 5 pounds. Apples never contain sulfur dioxide in excess of the legal maximum. In fact they do not easily absorb and retain sufficient SO_2 to preserve their color during storage. The time of sulfuring varies from 20 minutes to 1½ hours. The texture does not break down from exposure to the fumes as with apricots and peaches.

Evaporating.—All apples are artificially dried in either the natural-draft drier or evaporator or the forced-draft type known as a dehydrator. The former is still most often used, although the latter is becoming popular.

The kiln evaporator is the most common type of drier in use. In this the fruit is spread on the slat floor to a depth of 6–18 inches or more, and heated air from a furnace beneath is allowed to pass up through the fruit and out ventilators at the top of the kiln. The air temperatures maintained range from about 150° Fahrenheit in the initial stages to as high as 175° when the fruit has been in the kiln about half of the time required. In the final stages drying temperatures over 100° are not advisable. Relative humidities in the exhaust air range from 90 per cent at first to 35 per cent at the end of the drying period. The fruit is usually turned two or three times during drying, which for slices will require from 12 to 18 hours.

Air conditions in stack evaporators are similar to those in the kiln evaporator, but the drying time is reduced to 4–8 hours by placing the fruit on slat-bottom trays to a depth equal only to the diameter of the slices. Instead of the fruits being turned as in the kiln evaporator, the individual trays are shifted up or down during drying.

With tunnel dehydrators, in which the fruit passes through on shallow trays, dry air (relative humidity at the hot end 18–20 per cent) is

heated to 160°–165° Fahrenheit and passes over the fruit at the rate of 600 to 800 feet per minute. The usual time required for drying with this type of equipment is less than in the ordinary type of evaporator.

Fruit is usually considered sufficiently dry when a handful of slices pressed firmly together has an elastic, springy feel and separates at once when pressure is released. Federal regulations require that the moisture content of dried apples shall not exceed 24 per cent, while the standard of the Dried Fruit Association of California is 22 per cent. It is customary to pack apples with a moisture content close to those limits; but as some moisture must be added in the packing process, the fruit should be dried to below 22 per cent.

After removal from the evaporator or dehydrator, the fruit is placed in a large pile in a curing room, where overdry pieces will absorb moisture and those containing too much will lose their surplus. The entire mass should be turned each day or so, to insure uniformity. After this condition is reached, the fruit is ready for grading and packing. Different varieties of apples should be segregated since they require different times for cooking and since differences in color of the flesh reduce the uniformity of appearance.

Grading and Packing.—Individual growers doing their own drying usually deliver their apples in sacks to those operating commercial evaporators, to marketing associations, or to others equipped for grading and packing. The fruit is reprocessed by adding moisture and resulfuring; is then segregated into grades[39] according to size, color, and freedom from blemishes; and is packed in 25 and 50-pound boxes. The fruit is put in from the bottom side of the box, the first layer being sealed and placed by hand so that when the top of the pack is exposed it will have an attractive face. After this first layer is placed, the rest of the package is simply filled with loose fruit, which is packed in until the required weight is secured.

California Evaporated-Apple Grades.—The grades by which California dried or evaporated apples may be classified are Fancy, Extra Choice, Choice, and Standard.

Fancy apples must be slices from sound, mature, large fruit. The color should be extra bright and uniform for the variety, and different varieties of different color should be kept and boxed or sacked separately. The apples should be free from decay, mold, and worm-eaten blemish, and should contain only a low percentage of other defects, and screenings. There should be a high percentage of ring apples.

[39] Grades for California evaporated apples may be secured from the Dried Fruit Association of California, 1 Drumm St., San Francisco, California.

Extra Choice apples must be slices from sound, mature fruit of reasonably uniform medium or large size. The color must be bright and uniform for the variety, and different varieties of different color should be kept and boxed or sacked separately. They should be practically free from blemishes, foreign matter, cores, skin, and screenings. Pieces showing green skin should be few; those showing red skin, even fewer. The quantity of screenings should be low, but may be greater than that tolerated in the Fancy grade. The tolerance for core damage, too, is greater; and the percentage that should be rings is smaller.[40]

Choice apples should be slices from sound, mature fruit of large, medium, or small size, reasonably free from blemishes, cores, and skin. Though at present no objection is made to lack of uniformity of color, the color must be characteristic of the variety. The tolerance for pieces showing skin, for the quantity of screenings present, and for core damage is more lenient than for the Extra Choice grade.

Standard apples are slices conforming to the United States Government and California State Pure Food Regulations but not meeting the requirements of Choice.

Quartered apples may be apples cut in 3, 4, or 6 approximately equal pieces. Grade specifications are the same as for the corresponding grades of sliced apples as to size, quality, color, separation of varieties, and workmanship, excepting that the Fancy, Extra Choice, or Choice quartered apples must be free of screenings. There is a relatively low tolerance on the presence of halves. Whole apples are not tolerated.

CANNED APPLES[41]

Apples are canned extensively in the Pacific Northwest and the Eastern United States, but seldom in California.

Canning is considered a by-product industry in most apple-growing districts as a means of utilizing the best culls. Fruit for canning should be fair-sized and as free of blemishes as possible. Acid varieties with white, firm flesh are preferred. On the Pacific Coast the Yellow Newtown, and Spitzenberg are popular.

In preparation for canning the fruit is first washed and graded, then peeled and cored by machine. The peeled and cored fruit should then

[40] Exact tolerances are not given because they vary from year to year and sometimes with the district. This information should be obtained from the industry for any particular year.

[41] For further details see:

Campbell, Clyde H. Campbell's book. 246 p. Canning Age Publishing Company, New York, N. Y. 1930.

Cruess, W. V. Commercial fruit and vegetable products. p. 116–118. McGraw-Hill Book Company, New York, N. Y. 1924.

be trimmed, quartered, and held in a 3 per cent brine to prevent darkening. It is then treated to remove the oxygen by being (1) steamed at 180° Fahrenheit for 6 minutes, (2) held in warm water at 120° for ½ to 2 hours, or (3) subjected, while in warm water, to a 20-inch vacuum for 10 minutes.

After the deaeration treatment the fruit is packed into No. 10 cans as solid pack, or a little boiling water or dilute brine is added. In most cases, however, the solid pack is used. The cans should be filled at 150° to 160° Fahrenheit, exhausted 8 minutes in steam, and cooked (after sealing) at 212° for 20 to 30 minutes. The exhaust for the wet packs is 3 to 4 minutes in steam, and the cook is 8 to 10 minutes at 212°. The exhaust and time periods vary with the pretreatment and the size of can.

APPLES FOR BAKERS' USE AND OTHER APPLE PRODUCTS[42]

When preparing apples for bakers' use, the fresh fruit is peeled, cored, and dipped in a 0.2 per cent solution of sulfurous acid for a few minutes. It is then removed, sliced, and redipped. If a 0.2 per cent solution is used the fruit must be submerged for 1 hour in order to retain a white color. In a 0.3 per cent solution a 10-minute dip will suffice.

Fruit treated in this manner may be distributed to bakers for immediate use in making fresh-apple products or may be packed in cans and frozen for future use. In either case it retains a desirable light color.

Apple products produced on a lesser scale than those named above include canned apple sauce, vinegar, cider, and brandy.[43]

STANDARDS OF APPLE PRODUCTION COSTS[44]

Standards of cost per acre and per box of producing Gravenstein apples in Sonoma County and late apples in Santa Cruz County are shown in tables 6 and 7. As will be noted, the detailed costs are divided into five principal groups: labor, material, cash overhead and depreciation, and interest. These data are based primarily upon records kept by apple growers who coöperated with the Agricultural Extension Service for five years in conducting apple enterprise-efficiency studies in the two counties. The studies indicate a wide variation existing between individual orchards in production costs and management practices. These records

[42] Detailed information may be obtained from the following reference: Joslyn, M. A., and E. M. Mrak. Investigations on the use of sulphurous acid and sulfites in preparation of fresh and frozen fruit for bakers' use. Fruit Prod. Jour. 12:135–40. 1933.

[43] Apple pectin, which is not produced in California, is treated in: Rooker, W. A. Fruit pectin. 170 p. Avi Publishing Company, New York, N. Y. 1928.

[44] This section has been prepared by B. B. Burlingame, Extension Specialist in Farm Management.

show that many growers could increase their net earnings by improving practices.

The object here in presenting tables 6 and 7 is not to give so-called "county averages" nor, on the other hand, ideal theoretical situations, but rather to show desirable orchard-management setups that approximate actual conditions as found on the more profitable orchards in the

TABLE 6

A STANDARD OF COSTS FOR PRODUCTION OF GRAVENSTEIN APPLES IN A MATURE ORCHARD IN SONOMA COUNTY, CALIFORNIA*

Operations	Labor costs				
	Man labor per acre	Tractor work per acre	Truck work per acre	Cost per acre	Cost per box
	hours	*hours*	*hours*	*dollars*	*cents*
Pruning	35.0	....	....	10.50	2.1
Brush disposal	3.0	1.0	....	1.75	0.4
Hauling and applying fertilizer	3.0	....	3.0	3.15	0.6
Dormant spray	7.5	2.5	....	4.37	0.9
Other sprays	28.5	9.5	....	16.63	3.3
Disking two ways—turning under cover-crop	1.5	1.5	....	1.72	0.3
Disking or cultivating two ways—weed control	1.5	1.5	....	1.73	0.3
Miscellaneous	4.0	1.0	1.0	2.80	0.6
Subtotal for early cultural operations	84.0	17.0	4.0	42.65	8.5
Thinning	30.0	....	....	9.00	1.8
Bracing and propping	3.0	....	0.7	1.40	0.3
Subtotal for all cultural operations	117.0	17.0	4.7	53.05	10.6
Picking 360 boxes from tree (at 9 cents)	108.0	....	....	32.40	7.4
Picking 140 boxes from ground (at $1.50 per ton)	16.0	....	....	4.80	
Hauling	14.0	....	11.0	12.45	2.5
Subtotal for harvesting	138.0	....	11.0	49.65	9.9
Total labor costs	255.0	17.0	15.7	102.70	20.5

Material costs

	dollars	*cents*
Fertilizer—manure	8.00	1.6
Dormant spray—oil and spreader $0.45 per 100 gal. = $2.25; rig operation $0.25	2.50	0.5
Other sprays (3) 62½ lb. lead=$6.88; 94 lbs. sulfur at $3.52; spreader=$1.33; rig=$0.95	12.68	2.5
Miscellaneous material	2.00	0.4
Total material costs	25.18	5.0

Carried forward

TABLE 6—(*Concluded*)

A Standard of Costs for Production of Gravenstein Apples in a Mature Orchard in Sonoma County, California*

Cash overhead costs

		Brought forward
	dollars	*cents*
General expense, 5 per cent of total labor and material costs	6.39	1.3
County taxes	5.00	1.0
Machinery and equipment repairs	2.00	0.4
Compensation insurance	1.00	0.2
Total cash overhead costs	14.39	2.9
Total cash and labor costs (cumulative)	142.27	28.4

Depreciation costs

	dollars	*cents*
Depreciation on trees	12.50	2.5
Depreciation on buildings and improvements	1.00	0.2
Depreciation on tillage tools	1.30	0.3
Depreciation on spray rig	1.67	0.3
Depreciation on props and braces	1.05	0.2
Depreciation on ladders, lug boxes, picking bags, and miscellaneous	1.96	0.4
Total depreciation costs	19.48	3 9
Total cash, labor, and depreciation costs (cumulative)	161.75	32.3

Interest costs

	dollars	*cents*
Interest on average value of trees, $250 at 5 per cent	12.50	2.5
Interest on average value of buildings and improvements, $20 at 5 per cent	1.00	0.2
Interest on average value of tillage tools, $7.60 at 5 per cent	0.38	0.1
Interest on average value of spray rig, $12.40 at 5 per cent	0.62	0.1
Interest on average value of props and braces, $8.00 at 5 per cent	0.40	0.1
Interest on average value of miscellaneous and harvest equipment, $8.80 at 5 per cent	0.44	0.1
Interest on value of land, $250 at 5 per cent	12.50	2.5
Total interest costs	27.84	5.6
Total all costs	189.59	37.9

* These data are based upon a 20-acre orchard unit of twenty-year-old trees, planted 70 per acre, with a yield of 500 45-lb. boxes per acre of orchard-run fruit. Labor costs are computed with a wage rate of $0.30 per hour for man labor, and a total operating cost per hour of $0.85 for tractor, and $0.75 for truck.

county studies. They are intended to be used by growers as a basis of comparison and also to help those not familiar with the costs involved on good apple orchards in the two districts.

Most items of cost are self-explanatory except that of general expense listed under cash overhead. This is computed at 5 per cent of the total

labor and material costs and is included to cover miscellaneous expenses such as interest on operating capital, use of the family car in connection with the enterprise, telephone, and office. In establishing field-power rates and depreciation and interest costs on equipment and facilities, an orchard unit of 20 acres has been assumed. Field power supplied by a

TABLE 7

A STANDARD OF COSTS FOR PRODUCTION OF LATE APPLES IN A MATURE ORCHARD IN SANTA CRUZ COUNTY, CALIFORNIA*

Operations	Labor costs				
	Man labor per acre	Tractor work per acre	Truck work per acre	Cost per acre	Cost per box
	hours	*hours*	*hours*	*dollars*	*cents*
Pruning	60.0	....	....	18.00	2.1
Brush disposal	4.0	2.0	....	2.90	0.4
Planting covercrop	1.0	1.0	....	1.15	0.1
Hauling and applying fertilizer	1.0	....	1.0	1.05	0.1
Dormant spray	8.4	2.8	....	4.90	0.6
Other sprays	31.5	10.5	....	18.38	2.2
Disking two ways—turning under covercrop	1.5	1.5	....	1.72	0.2
Disking or cultivating two ways—weed control	1.5	1.5	....	1.73	0.2
Miscellaneous	4.0	1.0	1.0	2.80	0.3
Subtotal for early cultural operations	112.9	20.3	2.0	52.63	6.2
Thinning	120.0	....	....	36.00	4.3
Bracing and propping	6.0	....	1.5	2.92	0.3
Subtotal for all cultural operations	238.9	20.3	3.5	91.55	10.8
Picking 720 boxes from trees (at 6 cents)	144.0	....	....	43.20	5.6
Picking 130 boxes from ground (at $1.50 per ton)	15.3	....	....	4.59	
Hauling	30.0	....	22.0	25.50	3.0
Subtotal for harvesting	189.3	....	22.0	73.29	8.6
Total labor costs	428.2	20.3	25.5	164.84	19.4

Material costs

	dollars	*cents*
Fertilizer—300 pounds commerical	6.00	0.7
Covercrop seed	2.50	0.3
Dormant spray oil and spreader $0.60 per 100 gal.=$3.36; rig operation=$0.28	3.64	0.4
Other sprays (3) 75.6 lbs. lead at $0.11=$8.32; spreader=$1.47; rig=$1.05	10.84	1.3
Miscellaneous material	2.00	0.2
Total material costs	24.98	2.9

Carried forward

TABLE 7—(*Concluded*)

A STANDARD OF COSTS FOR PRODUCTION OF LATE APPLES IN A MATURE ORCHARD IN SANTA CRUZ COUNTY, CALIFORNIA*

Cash overhead costs

		Brought forward
	dollars	*cents*
General expense, 5 per cent of total labor and material costs	9.49	1.1
County taxes	5.00	0.6
Machinery and equipment repairs	2.00	0.2
Compensation insurance	1.70	0.2
Total cash overhead costs	18.19	2.1
Total cash and labor costs (cumulative)	208.01	24.4

Depreciation costs

	dollars	*cents*
Depreciation on trees	12.50	1.5
Depreciation on buildings and improvements	1.00	0.1
Depreciation on tillage tools	1.30	0.2
Depreciation on spray rig	1.67	0.2
Depreciation on props and braces	2.00	0.2
Depreciation on ladders, lug boxes, picking bags, and miscellaneous	2.45	0.3
Total depreciation costs	20 92	2 5
Total cash, labor, and depreciation costs (cumulative)	228.93	26.9

Interest costs

	dollars	*cents*
Interest on average value of trees, $250 at 5 per cent	12.50	1.5
Interest on average value of buildings and improvements, $20 at 5 per cent	1.00	0.1
Interest on average value of tillage tools, $7.60 at 5 per cent	0.38	...
Interest on average value of spray rig, $12.40 at 5 per cent	0.62	0.1
Interest on average value of props and braces, $15.00 at 5 per cent	0.75	0.1
Interest on average value of miscellaneous and harvest equipment, $12.20 at 5 per cent	0.61	0.1
Interest on value of land, $300 at 5 per cent	15.00	1.8
Total interest costs	30.86	3.7
Total all costs	259.79	30.6

* These data are based upon a 20-acre orchard unit of thirty-year-old trees, planted 70 per acre, with a yield of 850 47-lb. boxes per acre of orchard-run fruit. Labor costs are computed with a wage rate of $0.30 an hour for man labor, and a total operating cost per hour of $0.85 for tractor, and $0.75 for truck.

light tractor and truck is most prevalent and practical on a unit of this size. These figures should be considered as an average over a period of years, since operations like pruning, fertilizing, and thinning will vary from year to year.

To calculate harvesting costs per acre as well as costs per box, an average yield of orchard-run fruit for the Gravensteins was set at 500 boxes

per acre of 45 pounds each; for the late apples, 850 boxes of 47 pounds. These yields correspond to those of the better orchards. Of the total yield only 360 boxes of Gravensteins and 720 boxes of the late apples were assumed picked from the tree, whereas the remainder of the crop was harvested from the ground at a much lower cost. Attention is called to the fact that some of the tree-picked fruit will be culls not sold as boxed apples. The net cost of producing a so-called "packed box" could be calculated by deducting from the total cost the income from cull apples and those picked from the ground, which were disposed of for other purposes, and dividing this figure by the actual number of packed boxes. It is well to point out that high yield per acre is by far the most important factor in obtaining low-cost production.

Where irrigation is practiced, in the Santa Cruz district, costs for this operation will have to be added in table 7. Such costs would be justified only by sufficient increase in production to offset them. This problem must be solved by the individual grower.

A maximum cost of bringing trees into bearing was considered to be $500 per acre; and a productive life, forty years. Annual depreciation, therefore, is $12.50 per acre. Interest has been figured on one-half the average value of $500, or $250. Interest on improvements and equipment is figured on the average values, or one-half the original cost.

YIELDS AND RETURNS

Differences in soil, climatic conditions, varieties, age of trees, and general care given the orchards cause wide variation in apple yields.

The largest and most uniform yields are doubtless secured in the Pajaro Valley, where the majority of orchards, under good care produce average yields of 400 to 450 boxes per acre. From the better orchards 600 to 1,200 boxes may be produced. In the Gravenstein section of Sonoma County the general average yields of full-bearing orchards vary from 250 to 450 boxes per acre, the size of the yield depending largely upon the season. The more successful growers may secure 500 to 700 boxes to the acre. In both these sections, individual orchards in certain seasons may give much higher yields, but these are exceptional.

In other sections, individual orchards will doubtless compare favorably with these figures, although because of younger trees or the lack of proper care the general average of an entire district will be lower. Even in the best-producing sections there are orchards whose yields are extremely low, and only those on the better soils and under the best management will give satisfactory yields.

Average returns from the apple crop for the years 1926–1935 expressed as "farm value" are given in table 1. Figures of the Sebastopol

Apple Growers' Union show net returns on the Fancy grade of Gravensteins for the ten-year period 1926–1935 to have averaged approximately $0.75 a box. Net returns in different years have fluctuated from the extremely low price of $0.19 a box in 1932 to $1.58 in 1929. Windfalls and other fruit not suitable for packing have usually sold at about $10.00 a ton.

Highly colored and well-graded winter varieties from the smaller sections at higher elevations return from $0.75 to $1.50 a box, according to the individual variety and the amount of fruit available.

In the Watsonville section, where most growers sell their unpacked crop to local buyers, returns during the years 1930–1936 have been from $15.00 to $25.00 a ton[45] for the Yellow Newtowns and from $12.00 to $22.00 a ton[46] for Yellow Bellflowers. On a box basis these prices may appear not to compare favorably with those from other sections; but the figures are for the crop orchard run and involve no packing or selling expenses. In determining actual net profit one must also consider the larger average yields secured.

Although returns reflect the general condition of the industry, their significance can be fully realized only by the grower who knows his costs of production. High returns per box do not necessarily mean large profits for low yields and extra cost for spraying, thinning, or marketing affect profit regardless of price.

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[45] Approximately 55 boxes to the ton.

[46] Approximately 60 boxes to the ton.

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